UNIVERSITÉ Concordia UNIVERSITY

ENVIRONMENTAL
HEALTH AND SAFETY

LABORATORY SAFETY MANUAL

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Table of Contents

Abbreviations ..... **i**

Definitions ..... **ii**

1. Introduction **1**

2. Scope **1**

3. University Health & Safety Policies **1**

4. Responsibilities **2**

4.1. General Responsibilities *2*

4.2. EHS Research Compliance Review *2*

4.3. University Hazardous Materials Committee (UHMC) *3*

4.4. Legislation *3*

4.4.1. Act Respecting Occupational Health and Safety (L.R.Q., c. S-2.1) 3

4.4.2. Regulation Respecting Occupational Health and Safety (c.S-2.1, r.19.01) 4

4.4.3. The Criminal Code (R.S.C., 1985, c. C-46) 4

4.4.4. CNESST 4

4.5. Due Diligence *5*

4.5.1. Demonstrating Due Diligence 5

4.6. Training *6*

4.7. EHS External Training Recognition *6*

4.8. Laboratory Signage *7*

4.9. Laboratory Inspections *7*

4.10. Hazard Assessments & Standard Operating Procedures *7*

4.11. Laboratory and Equipment Decommissioning *8*

5. Laboratory Design **9**

5.1. Laboratory Ventilation *9*

5.1.1. General Laboratory Ventilation 9

5.1.2. Laboratory Doors 9

5.2. Chemical Fume Hoods *9*

5.2.1. How to Use the Fume Hood 9

5.2.2. Face Velocity 10

5.2.3. Emergency Purge 10

5.2.4. Maintenance 10

5.3. Safety Equipment *11*

5.3.1. Emergency Eyewash Stations / Safety Showers 11

5.3.2. Emergency Shut-Offs 12

5.3.3. Fire Extinguishers 12
5.3.4. First Aid Kits 14

6. Safe Work Practices 14

6.1. Routes of Exposure 14

6.2. Laboratory Conduct 15
6.2.1. General Safe Laboratory Practices 15
6.2.2. Housekeeping 15
6.2.3. Working Alone 16
6.2.4. Unattended Experiments 17
6.2.5. Laboratory Visitors 17

6.3. Pregnant Students/Staff – New Mothers 17

6.4. Transportation / Shipping of Hazardous Materials 18
6.4.1. Within Buildings 18
6.4.2. By Ground Vehicle 18
6.4.3. By Plane (Air Shipments) 19

7. Chemical Hazards 19

7.1. Workplace Hazardous Materials Information System (WHMIS 1988) 19
7.1.1. Product Classification 20
7.1.2. WHMIS 1988 Chemical Labels 21
7.1.3. Material Safety Data Sheet (MSDS) 22

7.2. WHMIS 2015 23
7.2.1. Summary 23
7.2.2. WHMIS 2015 Classification 23
7.2.3. Supplier Label Requirements 24
7.2.4. Hazard Pictograms 27
7.2.5. Safety Data Sheet (SDS) 28

7.3. Working with Hazardous Chemicals 29
7.3.1. Very Toxic and Toxic Materials 29
7.3.2. Carcinogens, Mutagens, Teratogens and Reproductive Toxins 30
7.3.3. Sensitizers 31
7.3.4. Working Safely with Chemicals 31

7.4. Chemical Storage 32
7.4.1. General Guidelines 32
7.4.2. Compatibility 32
7.4.3. Storage of Flammable Materials 33

7.5. Peroxide Forming Solvents and Reagents 35

7.6. Compressed Gases Safety 36
7.6.1. Handling Requirements 37
7.6.2. Cylinder Set-Up 37
7.6.3. Storage Guidelines 37
7.6.4. Cylinders in Use 38
7.6.5. Storage Limits for Hazardous Gases 38
7.6.6. Special Ventilation Requirements 38
7.6.7. Asphyxiation – Carbon dioxide 39

7.7. Cryogenic Gases ... *39*
7.7.1. Cold Burns, Frostbite and Hypothermia ... 39
7.7.2. Asphyxiation – Liquid Nitrogen, Argon and Helium ... 40
7.7.3. Fire Hazards from Oxygen-Enriched Atmosphere ... 40
7.7.4. Liquid Oxygen Condensation ... 40
7.7.5. Over Pressurization ... 41
7.8. Liquefied Petroleum Gases (LPG) ... *41*
7.8.1. Definition and Associated Hazards ... 41
7.8.2. LPG Laboratory Use ... 41
7.8.3. LPG Storage Requirements ... 42
7.9. Oxidizing Gases ... *42*
7.10. Acetylene ... *42*
8. Nanomaterials & Nanoparticles ... 43
9. Biological Hazards ... 43
10. Radiation Hazards ... 43
11. Magnetic Field Hazards ... 44
12. LASER Hazards ... 44
13. Hazardous Waste ... 44
13.1. Responsibilities ... *44*
13.1.1. Faculty, staff, students, volunteers and visitors ... 44
13.1.2. Environmental Health & Safety (EHS) ... 45
13.2. Chemical Waste ... *45*
13.2.1. Containers for Chemical Waste ... 46
13.2.2. Expired Chemicals ... 47
13.2.3. Empty Chemical Containers ... 47
13.2.4. Chemical Waste Pick-Up Procedure ... 47
13.2.5. Guidelines ... 47
13.3. Biohazardous Waste ... *48*
13.3.1. Containers for Biohazardous Waste ... 48
13.3.2. Decontamination Prior to Disposal ... 49
13.3.3. Biohazardous Waste Pickup Procedure ... 49
13.3.4. Guidelines ... 49
13.4. Radioactive Waste ... *50*
13.4.1. Categories / Disposal ... 50
13.4.2. Radioactive Waste Pickup Procedure ... 51
13.4.3. General Guidelines ... 51
13.5. Sharps ... *51*
13.5.1. Categories / Disposals ... 51
13.5.2. Guidelines ... 52
13.6. Mixed Waste ... *52*
13.6.1. Disposal ... 52

13.7. Other Types of Hazardous Waste *52*
13.7.1. Disposal 52
13.7.2. Concordia Recycling Depot Locations 52
13.8. Non-Compliance *53*

14. Physical Hazards 53

14.1. Electrical Safety *53*
14.1.1. General Electrical Safety 53
14.1.2. Static Electricity 54
14.2. UV Radiation *54*
14.3. Glassware *55*
14.4. Ergonomics *56*
14.5. Noise *57*

15. Equipment Safety 57

15.1. Refrigerators and Freezers *58*
15.2. Centrifuges *58*
15.3. Autoclaves *59*
15.3.1. General Guidelines 59
15.3.2. Autoclave Loading 59
15.3.3. Autoclave Unloading 60
15.4. Sonicators, Mixers and Grinders *60*
15.5. Bunsen Burners *60*
15.6. Hot Plates, Ovens and Microwaves *61*
15.7. Water Baths *61*

16. Personal Protective Equipment (PPE) 62

16.1. Laboratory Clothing *62*
16.2. Gloves *64*
16.2.1. General Guidelines 65
16.2.2. Glove Selection 66
16.2.3. Allergies 66
16.3. Eye and Face Protection *66*
16.3.1. Proper Fit 67
16.3.2. Care 67
16.3.3. Face Shields 67
16.3.4. Contact Lenses in the Laboratory 67

Emergency Procedure 69

16.4. Respiratory Protection *69*
16.5. Hearing Protection *69*

17. Emergency Procedures 69

17.1. Injury and Incident Reporting 69

17.2. Fire and Egress 70
17.2.1. Fire 70
17.2.2. Egress 71

17.3. Power Failure 71

17.4. Spills 71
17.4.1. Incidental Spill (or Minor Spill) 71
17.4.2. Emergency Spill (or Major Spill) 72
17.4.3. Spill Kits 72

18. References 73

Appendix I : Template of Training Record 75

Appendix II: Segregation of Incompatible Chemical Classes 76

Appendix III: Peroxide forming chemicals and solvents 79

Appendix IV: [Flammable or Toxic] Compressed and Liquefied Gases 81

Appendix V: Typical Laboratory Spill Kits 82

Abbreviations

ANSI	American National Standards Institute
BSO	Biosafety Officer
CCOHS	Canadian Centre for Occupational Health and Safety
CNT	Carbon Nanotubes
CO_2	Carbon Dioxide
CSO	Chemical Safety Officer
CSA	Canadian Standards Association
CSBN	Centre of Studies in Behavioral Neurobiology
CNESST	Commission des Normes, de l'Équité, de la Santé et de la Sécurité du Travail
EHS	Environmental Health and Safety
ft.	Foot / feet
GHS	Globally Harmonized System of Classification and Labelling of Chemicals
HEPA	High Efficiency Particulate Air
IATA	International Air Transport Association
LPG	Liquefied Petroleum Gas
LSO	LASER Safety Officer
MPE	Maximum Permissible Exposure
MSDS	Material Safety Data Sheet
NFPA	National Fire Protection Association
NIOSH	National Institute for Occupational Health and Safety
PI	Principal Investigator
PPE	Personal Protective Equipment
RSO	Radiation Safety Officer
SDS	Safety Data Sheet
SOP	Standard (or Safe) Operating Procedure
STM	Société de Transport de Montréal
TDG	Transportation of Dangerous Goods
VPS	Vice-President Services
WHMIS	Workplace Hazardous Materials Information System

Definitions

Biohazardous Material
Biohazardous materials are defined as materials of biological origin that are potentially harmful to humans, animals, plants, or to the environment. Biohazardous materials include, but are not limited to:

- Microorganisms such as viruses, fungi, parasites, bacteria and their toxic metabolites
- Mammalian primary tissues, blood and body fluids;
- Materials that may contain the above-mentioned agents (e.g. cell cultures, specimens from humans and animals, environmental samples);
- Certain proteins
- Certain nucleic acids (siRNA, miRNA, DNA from pathogenic organisms, oncogenes);
- Genetically modified organisms (GMO) that may be hazardous to the environment if released.

Controlled Product
Any product included in the classification established by regulation or meeting the criteria set out in the classification. A controlled product could be included in one or more of the following classes: compressed gas; flammable or combustible material; oxidizing material; poisonous or infectious material; corrosive material; dangerously reactive material. [Act Respecting Occupational Health and Safety R.S.Q., chapter S-2.1]

The Quebec Bill 43, *"An Act to enhance the communication of hazard-related information concerning products present in the workplace and to amend the Act respecting occupational health and safety",* amended the *Act Respecting Occupational Health and Safety* to replace the concept of "Controlled Product" by that of "Hazardous Product". The newly modified Act defines a **Hazardous Product** as:

- Any product, mixture, material or substance governed by subdivision 5 of Division II of Chapter III and determined by a regulation made under this Act".

The regulations adopted under the *Act Respecting Occupational Health and Safety (chapter S - 2.1)* were amended to harmonize them with the new classification of hazardous products, the expressions listed in Schedule I of this Act, that designate a class of controlled products classified in accordance with the Controlled Products Regulations (SOR/88-66), designate the corresponding hazard classes listed in the Hazardous Products Regulations (SOR/2015-17) and set out in the Schedule.

Emergency Spill (or Major Spill)[1]
A release of hazardous material which:

- Poses a significant safety or health hazard to persons in the immediate vicinity; or
- Poses a significant risk of environmental damage.

A spill is classified as an emergency spill due to the properties of the hazardous materials (toxicity, volatility, flammability, explosiveness, corrosiveness, etc.) and/or the circumstances of the release (quantity, location, space considerations, availability of ventilation, heat and ignition sources, etc.).

[1] *Spill definitions are in accordance with the Occupational Safety and Health Administration (OSHA) of the United States Department of Labor. More details can be obtained on the OSHA website at www.osha.gov/html/faq-hazwoper.html#faq8.*

Hazardous Material

As per Section 1, Paragraph 21 of the *Quebec Environment Quality Act*, a hazardous material is:
"a material which, by reason of its properties, is a hazard to health or to the environment and which, within the meaning of a regulation under this Act, is explosive, gaseous, flammable, poisonous, radioactive, corrosive, oxidizing or leachable or is designated as a hazardous material, and any object classed by regulation as a hazardous material."
Examples of hazardous materials include, but are not limited to:

- Flammable solvents (e.g. methanol, ethanol, acetone, hexane, toluene, benzene, acetonitrile, diethyl ether, mineral spirits);
- Chlorinated (halogenated) solvents (e.g. chloroform, dichloromethane or carbon tetrachloride);
- Acids (e.g. hydrochloric acid, sulfuric acid, nitric acid)
- Caustics (e.g. sodium hydroxide, ammonium hydroxide)
- Fuels (e.g. gasoline, diesel, biodiesel);
- Paints (e.g. latex, acrylic, oil-based), dyes, stains, varsol and paint thinner;
- Oils, greases, lubricants and antifreeze;
- Mercury, lead, arsenic and other heavy metals;
- Batteries (lead/acid, lithium, alkaline);
- Laboratory reagents (solids, liquids and gases);
- Polychlorinated biphenyls (PCBs);
- Radioactive materials and waste;
- Biohazardous material (see definition) and waste.

Hazardous Waste

A Hazardous Product that is intended for disposal or is sold for recycling or recovery. [Hazardous Products Act, R.S.C., 1985, c. H-3]

Incidental Spill (or Minor Spill) [2]

A release of hazardous material which **does not**:

- Pose a significant safety or health hazard to persons in the immediate vicinity or to the person cleaning it up;
- Pose a significant hazard to the environment; and
- Have the potential to become an emergency within a short time frame.

Incidental spills are limited in quantity, exposure potential (human and environmental), and toxicity, therefore it represents a minor safety or health hazard to persons in the immediate work area or to the person assigned to clean it up.

MSDS or SDS

Material Safety Data Sheet or Safety Data Sheet, an information sheet detailing technical and hazard evaluation information on a hazardous material.

[2] *Spill definitions are in accordance with the Occupational Safety and Health Administration (OSHA) of the United States Department of Labor. More details can be obtained on the OSHA website at www.osha.gov/html/faq-hazwoper.html#faq8.*

Normal Hours of Operation
The hours of operation of each individual location, building, premises or department at the University, which may vary from one department to another (refer to Concordia University Policy VPS-6).

Supervisor
A faculty member, director, manager, principal investigator, technical supervisor or any other person having direct responsibility for the activities of an employee or student

TDG
Transport of Dangerous Goods, a national program to promote public safety during the transportation of dangerous goods. The TDG Directorate serves as the major source of regulatory development, information and guidance on dangerous goods transport for the public, industry and government employees.

University Sanctioned Activities
Sanctioned activities include, but are not limited to: working, conducting research, studying, working as an intern, visiting or volunteering.

University Spill Response Team
Environmental Health & Safety (EHS) personnel who are certified Technicians of Hazardous Waste Operations and Emergency Response under the Occupational Safety and Health Administration standard (OSHA 1910.120).

WHMIS
Workplace Hazardous Materials Information System (1988 and 2015 versions), a national system designed to ensure that all employers obtain the information they need to inform and train their employees properly about hazardous materials used in the workplace. WHMIS legislation has specific requirements for information and training, labeling and MSDS/SDS (Material Safety Data Sheets/Safety Data Sheets).

1. Introduction

Concordia University's Laboratory Safety Manual provides the information on the requirements related to safety and the prevention of injuries when conducting research, working, teaching and undertaking other activities involving hazardous materials at the University. These requirements are based on federal and provincial legislations, Concordia's internal policies, and existing best practices. Laboratory Supervisors are required to use this manual as a tool to teach safe work practices and procedures to staff and students for whom they are responsible.

2. Scope

The Laboratory Safety Manual applies to everyone engaged in work involving hazardous materials on University property, including laboratories, studios and workshops. The manual serves to establish minimum requirements for establishing a safe and healthy work environment, but must be supplemented with laboratory and task-specific information.

This manual applies to all Members of the University Community:

- Employees: a person who under a contract of lease of personal service or contract of apprenticeship, even without remuneration, carries out work for the University.
- Contract Workers: an employee working for another employer but carrying out work on University property.
- Students: an individual who has contracted with and is registered at the University for an academic purpose.
- Interns: students performing an internship (with or without remuneration) for a company or an institution.
- Visitors/Volunteers: an individual who is present on University Property who is neither an employee nor a registered student.

3. University Health & Safety Policies

Environmental Health and Safety (EHS) provides support to faculty and line management on matters of safety, occupational health and environment. It develops and oversees comprehensive health and safety programs encompassing all University activities and facilities. EHS ensures that the University is in compliance with legislation and accepted standards of practice, upholds the academic mission and supports the teaching, research and service activities of the University.

Concordia University has developed the following institutional policies that relate to laboratory safety:

- Environmental Health & Safety Policy (VPS-40)
- Policy on Working Outside The Hours of Operation or in Isolation (VPS-6)
- Policy on Personal Protective Equipment (VPS-41)
- Policy on Injury/Incident Reporting and Investigation (VPS-42)
- Policy on First Aid and Medical Emergency (VPS-45)
- Radiation Safety Policy (VPS-46)
- Policy for the Management of Hazardous Materials (VPS-47)
- Hazardous Materials Spill Response Policy (VPS-48)
- Laser Safety Policy (VPS-51)
- Biosafety Policy (VPS-52)

- Magnetic Field Safety Policy (VPS-54)

All Members of the University Community are responsible for reading and respecting the policies that apply to their specific work.

4. Responsibilities

4.1. General Responsibilities

The University has a responsibility to provide every employee and student with a safe environment in which to work and study. Concordia University will make every effort to protect the health, safety and physical well-being of its students, employees and visiting public.

Compliance with University health and safety policies and procedures is a condition of employment.

The University is required to comply with all federal, provincial and municipal laws, legislations, standards, labor codes and industrial safety acts that affect its employees and property.

Responsibility for laboratory safety is shared between the PI, staff and students, the departments and the University. As such, the PI acts as the manager of the laboratory and is responsible for ensuring a safe work environment for the employees and students working in the laboratory.

Due to the fact that every employee has the responsibility to comply with health and safety regulations and directives, all safety concerns should be reported to the immediate Supervisor.

The general responsibilities for all employees of Concordia University are described in the VPS-40 policy. This policy applies to the following:

- Senior Administrators, Deans and Executive Directors
- Managers and/or Supervisors
- Department Chairs, Research and Unit Directors
- Faculty members, researchers, instructors, technicians in Academic Departments and Teaching Assistants
- Employees and students
- And others, including contractors, service providers, visitors or any persons involved with the acquisition, handling, storage, removal or disposal of hazardous chemical products on University premises.

4.2. EHS Research Compliance Review

EHS has a mandate to ensure that research at the University is conducted in compliance with all applicable Health, Safety and Environmental regulations and standards. To that end, the EHS Research Compliance Review procedure allows EHS to ensure that:

- All risks are properly identified and controlled;
- Research facilities are appropriately equipped;
- Necessary internal and external permits, licenses and exemptions are obtained;
- Necessary standard operating procedures are implemented;
- All individuals involved (faculty, staff and students) are appropriately trained;

- All internal university policies and procedures are respected, and,
- All municipal, provincial and federal regulations and international conventions are respected.

Therefore, PIs, Faculty, Researchers and Course Instructors are responsible for:

- Obtaining EHS Compliance certificate for all research and teaching projects involving hazardous materials, equipment and/or processes, and prior starting such new activities or acquiring new equipment;
- Maintaining EHS compliance;
- Advising EHS of any changes to the research or teaching projects that may impact their existing approval;
- Ensuring that all persons working under their supervision have appropriate training, update their training as per regulation and university requirements, and work safely;
- Providing all the necessary personal protective equipment and review all standard operating procedures;
- Providing training to the standard operating procedures
- Providing orientation in the laboratory to any new researcher, staff member or student;
- Reporting to EHS any accidents or near misses according to VPS-42 policy.

In order to do so, PIs, Faculty, Researchers and Course Instructors must read the *EHS Research Compliance Review Procedure* (EHS-DOC-072) and fill up any of the necessary *EHS Research Compliance Review Forms* (EHS-FORM-066-Part 1 and EHS-FORM-067-Part 2), as requested by EHS.

Once reviewed by EHS, the applicant is issues an EHS Research Compliance Review Certificate.

4.3. University Hazardous Materials Committee (UHMC)

The University has created a University Hazardous Materials Committee (UHMC) composed of academic and technical experts. The UHMC advises the University administration, through the Vice-President, Services, on matters pertaining to the management of hazardous materials within University facilities and operations. The role of the UHMC is to advise and support EHS in developing policies and procedures regarding the management of hazardous materials which support the teaching, research and the service functions of the University, in conformity with pertinent legislation and recognized codes and standards of practice.

4.4. Legislation

4.4.1. Act Respecting Occupational Health and Safety (L.R.Q., c. S-2.1)

The objective of the Act is the elimination, at the source, of dangers to the health, safety and physical well-being of workers. It defines the employer's obligation to protect the health and safety of employees such as:

1) Ensure that the workplace is safe for employees to perform their duties
2) Inform employees of their health and safety representative(s)
3) Ensure that the health and safety of anyone in the workplace is not compromised by the use of hazardous materials or contaminants
4) Provide the necessary personal protective equipment free of charge
5) Identify and eliminate or control the risks which may affect the health or safety of employees.

Please also refer to the *Act Respecting Industrial Accidents and Occupational Diseases* (A-3.001) available online.

4.4.2. Regulation Respecting Occupational Health and Safety (c.S-2.1, r.19.01)

The purpose of this regulation is to establish standards pertaining in particular to air quality, temperature, humidity, heat stress, lighting, noise and other contaminants, sanitary facilities, ventilation, hygiene, sanitation and cleanliness in establishments, area conditions, storage and handling of dangerous substances, machine and tool safety, certain high risk tasks, individual protective equipment and the transportation of workers; and to ensure the quality of the work environment, to safeguard the health of workers, their safety and physical well-being.

4.4.3. The Criminal Code (R.S.C., 1985, c. C-46)

Bill C-45 was adopted on March 31, 2004 and amended the *Canadian Criminal Code* to include a legal duty regarding health and safety under Section 217.1 of the Criminal Code.

> ***217.1*** *"Everyone who undertakes, or has the authority, to direct how another person does work or performs a task is under a legal duty to take reasonable steps to prevent bodily harm to that person, or any other person, arising from that work or task."*

The law includes legal duties for workplace health and safety, and imposes serious penalties for violations that result in injuries or death. It also establishes rules for attributing criminal liability to organizations and corporations for the actions of their representatives. It also creates a legal duty for all persons directing work to take "*reasonable steps*" to ensure the safety of workers and the public.

If these duties are carelessly disregarded and bodily harm or death results, an organization and/or individual could be charged with criminal negligence.
For more information on this, please have a look at Bill C-45 and Sections 22.1 & 22.2 of the Criminal Code imposing criminal liability on organizations and its representatives for negligence (22.1) and other offences (22.2). An overview is available at www.ccohs.ca/oshanswers/legisl/billc45.html.

4.4.4. CNESST

La Commission des Normes, de l'Équité, de la Santé et de la Sécurité du Travail (CNESST) is the organization to which the Government of Québec has entrusted the administration of the occupational health and safety plan.

For this purpose, the CNESST sees to the application of the following two Acts:

- the Act respecting occupational health and safety, which aims to eliminate at the source dangers to the health, safety and physical well-being ofworkers;
- the Act respecting industrial accidents and occupational diseases, which aims to compensate for work-related injuries and their consequences for workers, as well as the collection of the sums necessary to fund the plan from employers.

Table 4.4.4-1: CNESST Fields of Intervention

Prevention and inspection	Compensation and rehabilitation (VPS-43)
Support for workers and employers in their efforts to eliminate at the source the dangers present in their workplace	Compensation of workers having sustained a work-related injury
Inspection of workplaces	Rehabilitation of workers who, owing to a work-related injury, have sustained a permanent impairment to their physical or mental well-being
Promotion of occupational health and safety	

4.5. Due Diligence

In an occupational health and safety perspective, due diligence means that an employer shall take all reasonable precautions to prevent injuries or accidents in the workplace. Supervisors assume the responsibility of the employer in the context of due diligence.

In an educational institution, maintaining a safe and healthful workplace is considered due diligence for Supervisors.

A Supervisor is any individual overseeing the work, research or studies of a staff or student (with or without remuneration). They must exercise due diligence with regards to the health and safety of their workers.

A worker means a person, including a student in the cases determined by regulation, who, under a contract of employment or a contract of apprenticeship, even without remuneration, carries out work for an employer, except:

- a person employed as manager, superintendent, foreman or as the agent of the employer in their relations with their workers;
- a director or officer of a legal person, except where a person acts as such in relation to their employer after being designated by the workers or by a certified association.

4.5.1. Demonstrating Due Diligence

Records are essential to demonstrate due diligence. The EHS office offers a number of safety trainings; however, the Principal Investigator (PI) is expected to offer practical hands-on training to students and staff under their direct supervision. The training attendance form available on the EHS website can be used to document and ensure that the student/staff has been appropriately trained.

As such, the following documentation should be kept by Laboratory Supervisors:

- Training records (see template in Appendix I : Template of Training Record)
- Inspection reports
- Incident reports
- Orientation checklists
- Standard operating procedures

4.6. Training

Training is required to ensure that safe work procedures are in place. Supervisors must ensure that all individuals working in their laboratory receive appropriate training. EHS offers a number of live or on-line safety trainings throughout the year. Faculties and departments also organize safety trainings at the beginning of each semester.

EHS routinely offers the following trainings:

a) Workplace Hazardous Materials Information System (WHMIS 1988 and WHMIS 2015)
b) Hazardous Waste Disposal
c) Radiation Safety (including sealed sources, X-Ray devices and Refresher training)
d) Biosafety (including Refresher training)
e) Safe Handling of Blood
f) Safe Use of Biological Safety Cabinet
g) LASER Safety
h) Corrosive Substances
i) Transportation of Dangerous Goods - General
j) Transportation of Dangerous Goods Class 6.2 – Infectious Substances
k) Transportation of Dangerous Goods Class 7 – Radioactive Materials
l) Safe Handling of Nanomaterials
m) Minor Spill Response
n) Laboratory Safety Awareness (for non-scientific staff)

More details on EHS training sessions, training requirements and training schedule can be found on the EHS Safety Training webpage.

To be compliant with regulations, EHS maintains training and compliance records. Each year, Supervisors will receive a detailed review of the training sessions attended by staff and students under their responsibility. In addition, EHS can provide training information to Supervisors upon request. Also, any laboratory specific training can be entered in this database provided the EHS-FORM-032 is used and submitted to EHS (see Appendix I : Template of Training **Record**).

The Laboratory Supervisor must also ensure lab-specific training that focuses on the hazards present in their laboratory and develop Standard (or Safe) Operating Procedures (SOPs) specific to their laboratory activities (please refer to Section 4.10). The record of SOP presentation and/or orientations can be entered in the training database for convenience of record keeping.

4.7. EHS External Training Recognition

The Concordia University's EHS office will recognize certain safety training and/or certifications obtained from other institutions if the following criteria are met:

1) The training was obtained from a recognized Canadian institution/company.
2) The course content is equivalent to that given by the Concordia University EHS training program.
3) The training was taken less than 3 years ago.
4) The requester provides EHS with proof of successful completion of the training (e.g. training certificate or written confirmation).

However, if the individual is unable to provide a proof, they should provide EHS with the following information:

1) The name of the institution/company where the training was obtained.
2) His/her former student/employee ID.
3) The name of the department or person who provided the training.

Given that each request is evaluated on an individual basis and will take time to be analyzed, it is the individual's duty to be aware of the training(s) required to perform their daily duties and to contact EHS to request validation for any previously completed trainings prior to starting their experiments. EHS reserves the right to validate or refuse to recognize the training taken and individuals might be required to take the corresponding Concordia EHS training quiz for validation.

Any external safety training recognized by EHS is valid for a period of 3 years from the date it was originally taken.

4.8. Laboratory Signage

Warning signs have been posted outside each laboratory to indicate the type of hazard present within the lab. Any changes in the status or activities of a laboratory must be reflected in the signage by contacting Facilities Management (x2400).

Department Emergency Information cards must be completed and posted in each laboratory indicating the hazards present, the Laboratory Supervisor's contact information. In the event of an emergency in the laboratory the occupants are expected to bring the emergency card to Security in order to facilitate proper coordination and response to the emergency. The cards are available from EHS.

4.9. Laboratory Inspections

EHS conducts periodic laboratory safety inspections. The inspections are done in cooperation with PIs or their delegates, in order to ensure compliance with all the relevant legislation, internal procedures or guidelines, and best practices. Laboratory inspections provide a snapshot of laboratory safety and compliance.
A summary and a list of unsafe or unhealthy conditions identified during the inspection are sent to the PI. PIs are required to sign the Receipt Acknowledgement form confirming receipt of the inspection findings and return it to EHS, either by mail or electronic mail.

A copy of the Laboratory Safety Inspection Checklist is available on the EHS website.

4.10. Hazard Assessments & Standard Operating Procedures

Standard operating procedure (SOP) development is required for the use of LASERs, radiation sources, biological materials, strong magnetic fields, or any other University Policy-controlled activities. Specifications concerning specific SOP creation are also described in other different safety manuals (e.g. Biosafety, Radiation Safety, etc.) and additional guidelines can be found in the Laboratory Safety Programs section of the EHS website. An evaluation of the specific risks involved with the work performed in the laboratory must be done prior to starting any new projects. Each laboratory should supplement the general Laboratory Safety Manual with safe handling procedures or SOPs that are

specific to their laboratory activities.

Students and staff must be familiar with all work procedures and be informed of the hazards of the materials present in their work area. The evaluation and analysis required in preparing an SOP may help identify previously undetected hazards and further the dialogue between the PI, Laboratory Supervisor and staff/students.

Standard Operating Procedures should include:

- Names of responsible persons, emergency contact information, reference documents and purpose of the SOP.
- Detailed procedures and precautions to be used for handling hazardous materials and, in particular, toxic chemicals and carcinogens.
- Identification of materials and procedures that should be carried out in a fume hood or biological safety cabinet
- Details of necessary Personal Protective Equipment (PPE)
- Clean-up and/or decontamination procedures
- Emergency procedures in the event of a leak or spill
- Training requirements

A SOP writing training is also available from EHS upon request.

4.11. Laboratory and Equipment Decommissioning

PIs are responsible for their laboratory space and as such, must contact EHS prior to leaving a Concordia University laboratory. EHS will advise and help with the disposal of unwanted chemicals, along with the safe decommissioning of the laboratory. A certificate of equipment decommission must be filled out and a copy sent to the EHS office.

- Laboratories making use of open sources (e.g. radioisotopes) must provide a copy of their final wipe test to the Radiation Safety Officer (RSO) along with a signed copy of their decommissioning report. Please refer to the Radiation Safety Manual for more details.
- Laboratories working with biological materials should notify the Biosafety Officer (BSO) prior to stopping operation in order to ensure that the laboratory has been decontaminated and that all biological materials have been secured or properly disposed of. Please refer to the Biosafety Manual for more details.
- Laboratory equipment must also be properly decontaminated prior to their transfer, donation or disposal in order to remove any potential risk of contamination to external users. Also all energies must be removed from the equipment.

For more information or assistance about laboratory or equipment decommissioning, please contact EHS at the extension 4877 or at ehs@concordia.ca.

5. Laboratory Design

5.1. Laboratory Ventilation

5.1.1. General Laboratory Ventilation

The laboratories have a dedicated general laboratory ventilation system, separate from the ventilation of offices and public spaces. 100% of the air extracted from the laboratories is exhausted from the building. In addition, a laboratory's general ventilation system is balanced to maintain laboratories under negative pressure relative to adjacent areas in order to prevent potential contamination of adjacent areas.

A laboratory's general ventilation is not designed to control or exhaust volatile or toxic chemicals. All volatile and/or toxic chemicals must be handled in a chemical fume hood, under local ventilation, or using another appropriate containment enclosure. Avoid handling these hazardous materials on an open laboratory bench.

5.1.2. Laboratory Doors

To prevent contaminants from leaking into public areas, the ventilation system is designed to maintain the laboratories at negative pressure: the air flows from the corridor into the laboratories and is then exhausted outside. This design can only work efficiently when the laboratory doors are kept closed. An open laboratory door alters the air balance between the laboratory and the corridor which can cause chemical vapors to concentrate in the laboratory and escape into the hallways. Keeping doors open between rooms will compromise the safety of the laboratory and surrounding areas. **Closing laboratory doors is required for safety and hazard control.**

It is important not to cover or block the door windows. Emergency and security personnel must be able to see inside the laboratory in order to assist individuals during emergency evacuations and/or to assist security personnel in locating people in need of emergency assistance, especially after normal working hours.

Laboratory exits must always be clear and unobstructed.

5.2. Chemical Fume Hoods

A chemical fume hood is an engineering control used to capture hazardous vapors and gases and eliminate the persons' exposure to hazards. The use of engineering controls to reduce exposure must be instituted in priority over the use of personal protective equipment.

5.2.1. How to Use the Fume Hood

- Keep the sash closed when you are not working directly in front of the hood.
- Open the sash only when necessary during an experiment.
- Always keep the sash's opening at a normal operating position, leaving enough room for hands while observing your experiment through the lowered sash. The normal operating position is a specific height, typically in the 35 to 50 cm (14 to 20 inches) range. It should be indicated on the fume hood as a reminder.
- Always open the sash slowly; a sudden opening can cause air turbulence and push contaminants

into the main laboratory.

- Place all equipment at least 15 cm (6 inches) inside the fume hood, and ensure that experimental apparatus do not obstruct baffles or vents within the fume hood.
- All large equipment should be elevated 5 cm (2 inches) to diminish the effects of eddy currents that may reduce the efficacy of the hood.
- Heat-generating equipment should be placed at the back of the hood.
- Do not work with flammable materials in a hood that contains hot plates, open flames, or equipment that may generate electrical sparks.
- Use of the fume hood for storage should be minimized. A one or two day supply of materials should be considered the maximum quantity.

Fume hoods have limitations and additional PPE may be necessary in certain experiments.

5.2.2. Face Velocity

Each fume hood is equipped with a display panel or control box. Under normal operating conditions the display panel should **read between 85-100 ft. /min** and show a green LED light. This value can be as low as 50-60 ft. /min for the new generation of "low-flow" fume hoods. This value represents the face velocity, the speed of air entering the fume hood through the sash opening, and measured in the plane of the sash. Higher or lower face velocities will occur while the sash is being opened or closed. A yellow LED will be illuminated while the face velocity stabilizes. The display may be showing the values HI or LO at that time; it is fine to use the fume hood under these conditions.

In the event of an **alarm condition** a **red LED** will be illuminated and an audible alarm will sound. *Do not use the fume hood* until the alarm condition has been corrected. If the alarm condition doesn't correct itself after a short delay, close the sash and contact the Service Center at x2400. **Never disconnect the control box; this is the only way to know if the fume hood is working within the required standards.**

In the event of a power failure, the fume hood may not function anymore. Therefore, any experiment should be paused or halted.

5.2.3. Emergency Purge

The fume hood is equipped with an emergency purge button. This button can be used to exhaust any excess fumes resulting from a spill, an uncontrolled reaction or an explosion. Pressing this button will purge the fume hood by increasing the flow volume by one-and-a-half times the normal flow. The display will show EEE and a red LED light. This will continue until the button is pressed a second time to cancel the purge.

5.2.4. Maintenance

Standard maintenance and calibration of fume hoods is carried out annually by Concordia University Facilities Operations or a certified external contractor. When a particular fume hood requires maintenance, **the laboratory staff is responsible** for emptying and properly decontaminating their fume hood prior to the maintenance. A detailed list of chemical and biological agents used in the chemical fume hood may be requested for safety evaluation purposes.

If the fume hood is being used or has not been properly emptied at the time scheduled for its maintenance, Facility Operations will leave a notice on the fume hood sash indicating a new scheduled maintenance time.

Upon a second notice issued to laboratory users by Facility Operations regarding fume hood maintenance, **immediate action from the Laboratory Supervisor or the department Technical Officer will be required** in order to ensure proper and safe conditions for the fume hood maintenance by Facility Operations.

Facilities Operations may also issue notices of intent to perform maintenance work on the ventilation system. These notices shall be observed and chemical fume hoods shall not be used when Facilities Operations is repairing or adjusting the ventilation system.

5.3. Safety Equipment[3]

5.3.1. Emergency Eyewash Stations / Safety Showers[4]

Emergency showers and eyewash stations can provide rapid decontamination following exposure to a chemical or biological substance. They are located wherever there is a risk of accidental splashes of corrosive, toxic, or other hazardous materials to the skin or eyes such as in laboratories, workshops and studios. **Every laboratory worker and student must be aware of the location of the emergency eyewash and shower in their work area**. They must be trained on how to use the eyewash and shower in an emergency and to be prepared to assist others. The area around emergency equipment must be kept clear and free of obstructions at all times, including around countertop-mounted eyewash units.
The first few seconds following exposure to a hazardous material, especially corrosive chemicals, are critical:

- Flush the eye(s) or body immediately for at least 15 minutes; **delaying this action could result in permanent tissue damage**.
- Remove contaminated clothing while under the shower: **health has firstpriority**.
- Do not hesitate to use the eyewash or shower **even if the floor has no drains**.
- Have someone call Security (x3717) immediately for assistance.

The victim must seek medical attention as soon as possible after first aid has been given.

It is the responsibility of the Supervisor of the laboratory to ensure that Emergency eyewash Stations are tested weekly in order to:

- Verify that the water supply is appropriate (regular and homogenised flow between the outlets)
- Verify the water temperature
- Ensure the water is clear of sediments
- Minimize microbial contamination caused by stagnant water

The maintenance and calibration of emergency showers and eyewashes is carried out annually by Concordia University Facilities Operations.

[3] *A safety equipment is any equipment specifically designed to minimize or reduce harm or death.*
[4] *This safety equipment shall conform to the requirements of ANSI standard Z358.1-2014*

If a particular eyewash station requires maintenance, the **laboratory supervisor** is responsible for contacting Facility Management (x2400) to have the eyewash/safety shower fixed. More details get be obtained in Emergency Showers and Eyewash Stations Program.

Note: emergency showers can also be used for extinguishing clothing fires or for flushing contaminants off clothing.

5.3.2. Emergency Shut-Offs

Gas and electrical shut-offs are found in certain laboratories or on certain equipment. They must be clearly labeled. Equipment emergency shut-offs (ESO) are large red or yellow buttons generally located on or near the device. Laboratory electrical shut-offs are wall-mounted electrical switches. They are generally located near the device and will cut the power to the device.

Most laboratories are equipped with **gas shut-offs**. The gas shut-off access is located in the wall near the main laboratory door and is accessible from the laboratory or the corridor. In the event of a fire in the laboratory, occupants should shut off the gas in the room from the corridor by turning the lever handle to the off position, evacuate the laboratory and call Security (x3717).

Figure 5.3.2-1: Examples of electrical and gas shut-offs

5.3.3. Fire Extinguishers

Laboratories are provided with one or several fire extinguisher(s) suitable for the hazardous materials used and stored within the space. Fire extinguishers must be unobstructed and located in clear view. Laboratory staff and students should know the location and proper use of the fire extinguishers in their work areas.

Fire extinguisher training is available from Security. Please consult the Security training webpage.

There are 4 types of fire extinguishers, each efficient to fight a specific type of fire. These fires are classified by their fuel source and given identifying letters as showed in table 5.3.3-1.

Table 5.3.3-1: Types of Fire Extinguishers

Class A	Used for fires from combustible materials such as paper, wood, cardboard, and plastics.	
Class B	Used for flammable or combustible liquids such as solvents, gasoline, kerosene, grease and oil.	
Class C	Used for electrical equipment, such as appliances, computers, wiring, circuit breakers and outlets. You should never use water to extinguish a class C fire due to the risk of electrical shock.	
Class D	Used for combustible metals, such as magnesium, titanium, potassium and sodium.	

There are different types of fire, and there are different types of fire extinguishers. Some fire extinguishers contain chemicals that are ineffective in certain situations and cannot be used safely in these circumstances. Extinguishers are classified by the type of fire suppressant they contain.
A few of the most common extinguisher types are listed in next page.

Table 5.3.3-2: Uses of Fire Extinguishers

Water extinguishers APW extinguishers	Suitable for class A fires only. *A water extinguisher must never be used on grease fires, electrical fires or class D fires as the flames may spread.*
Carbon Dioxide (CO_2)	Used for class B and C fires. CO_2 extinguishers contain carbon dioxide, a non-flammable gas, and are highly pressurized.
ABC	Suitable for a combination of class A, B and C fires. Dry chemical extinguishers come in a variety of types. These are filled with foam or powder and pressurized with nitrogen. Labs that have the potential for a combination of these classifications may have an ABC type extinguisher.

These are the most common types of fire extinguishers but there are many others to choose from. Security will help select the correct type of extinguisher based on the classification and the extinguisher's compatibility with the work and materials in thelaboratory.

In the event of a fire, laboratory users are not expected to extinguish the fire themselves. Laboratory users who have been trained to use a fire extinguisher may attempt to extinguish the fire safely. To do so:

- Use a fire pull station, alert security, or assign someone to do so before dealing with a fire.

- Make sure a clear escape route is available before attempting to deal with the fire.
- If a laboratory user is trained to use a fire extinguisher and feels that the fire can be controlled, they may use the PASS method to extinguish the fire:
  - **P** – Pull and turn the locking pin to break the seal
  - **A** – Aim low by pointing the nozzle or hose at the base of the flames
  - **S** – Squeeze the handle to release the extinguishing agent
  - **S** – Sweep from side to side until the fire is out
- Extinguishers work for approximately 30 seconds: if the fire has not been extinguished in that time, leave the area immediately.
- When leaving, close the door and **do not lock it**.

New fire extinguishers or replacements can be obtained by contacting the Service Centre at x2400.

5.3.4. First Aid Kits

In accordance with the Concordia University VPS-45 Policy, each laboratory must have a properly stocked first aid kit, maintained under the responsibility of the Laboratory Supervisor or PI. First aid kits and supplies that comply with CNESST requirements are available for purchase from the Emergency Management via the online First Aid Supplies Ordering Form.

Injuries or illnesses which require first aid treatment must be reported to the immediate Supervisor and EHS by filling out an Injury/Near-Miss Report form.

6. Safe Work Practices

6.1. Routes of Exposure

There are five main routes of exposure by which products can contact and/or enter our bodies. Many hazardous materials can cause direct effects at the point of contact, such as irritation of the skin, eyes, mouth or nose. Some products can also be absorbed into the body and cause harmful effects on other body systems such as the blood, liver or nervous system. Some products are not harmful by any route of exposure, while others are harmful by some or all of the routes of exposure. The five main routes of exposure are:

- **Inhalation:** Hazardous products in the air can be inhaled into the body through the mouth or nose; in the laboratory and workplace, airborne products can occur in different forms such as gases, vapours (aerosols), dusts or mists.
- **Contact-Skin:** Hazardous products can cause direct effects at the point of contact with the skin. Some chemicals can be absorbed into the body through the skin.
- **Contact-Eye:** Hazardous products can also come in contact with the eyes as dusts, mists, gases, vapors, or when liquids are splashed; some can be absorbed through the eyes causing harmful effects elsewhere in the body.
- **Ingestion:** In workplaces, ingestion of hazardous products can result from hand-to-mouth contact, consuming contaminated food/drink, or smoking cigarettes that have come into contact with hazardous products or unclean hands; sometimes workplace hazardous products are accidentally swallowed.
- **Injection:** Hazardous products can enter the body via skin punctures or injection by needles or sharp objects contaminated with hazardous materials.

6.2. Laboratory Conduct

6.2.1. General Safe Laboratory Practices

The contamination of food, beverages, or smoking material is a potentially important route of exposure to toxic chemicals or biological agents through ingestion. Consequently, these **basic safety rules** must be followed by everyone working in or visiting a laboratory:

- WASH HANDS even if gloves are worn. Hand washing offers basic protection against inadvertent exposure to toxic chemicals or biological agents.
  - Always wash hands before leaving the lab
  - Always wash hands after removing gloves
  - Always wash hands before eating, drinking, smoking, or using the restroom
  - *Wash hands periodically throughout the day*
- CONFINE LONG HAIR, LOOSE CLOTHING, HEAD COVERING or HEAD SCARF when in the laboratory to keep them from catching fire, dipping into chemicals, or becoming entangled in moving machinery. *For similar reasons, jewelry should not be worn in the laboratory.*
- **Remove laboratory coats and gloves before leaving the laboratory** to prevent spreading contamination to other areas.
- DON'T CONTAMINATE PERSONAL BELONGINGS:
  - Leave personal items outside of the laboratory in order to prevent contamination (cell phone, car keys, tablet or laptop, MP3 player)
  - Keep work items (e.g. backpacks, notebooks, pencils, pens) off of bench areas where experiments are conducted
- LEAVE LAB SUPPLIES INSIDE THE LAB.
- REMOVE GLOVES BEFORE LEAVING THE LAB.

Laboratory personnel shall:

- NOT prepare, store, or consume food or beverages in the laboratory
- NOT pipette by mouth
- NOT smoke in the laboratory
- NOT apply lip balm or cosmetics
- NOT handle contact lenses in a laboratory area
- NOT wear ear phones or head phones in the laboratory
- NOT wear laboratory coats in public areas

6.2.2. Housekeeping

i. Workplace Organization

- All work areas, benches and floors must be clean, dry and uncluttered.
- Aisles should be clear of obstacles such as boxes, chemical containers, and other storage.
- Drawers and cabinet doors should be kept closed.
- Electrical cords should be secured off the floor to avoid tripping hazards.
- Spilled liquids should be cleaned up promptly to avoid slipping hazards.
- Exit doors and exit paths must be kept clear at all times.

- Safety equipment such as fire extinguishers and safety showers must be accessible and must be clear of obstacles.
- Supplies and equipment stored on top shelves must allow a 45 cm (18 inches) clearance so that fire sprinkler heads can be effective.
- Corrosive chemicals should never be stored above eye level.

ii. Discarding Material

When discarding empty boxes or other containers bearing hazardous material labels, **the labels must be defaced or removed before disposal**. Contaminated boxes or containers cannot be disposed of in the regular trash. Hazardous waste must be disposed of in accordance with University guidelines as described in Chapter 13 –Hazardous Waste.

iii. No Dry-Cleaning of Surfaces

Dry mopping or dry sweeping must not be done in laboratories using powdered hazardous materials, as this could cause the materials to become airborne.

Cleaning of laboratory equipment including refrigerators, freezers, fume hoods, biological safety cabinets and benches is the responsibility of laboratory personnel and must be conducted regularly in order to prevent accidental contact with hazards.

iv. Cleaning and Maintenance of Facilities

Custodial Services will remove regular garbage and clean floors that are clear and free of chemical products and any hazardous materials. Custodial Services is prohibited from cleaning up chemical and biological material and therefore cannot clean the interior of any fume hoods or biological safety cabinets unless they have been properly decontaminated.

In the event of a spill, refer to the **Emergency Procedures** section (Chapter 17- Emergency Procedures) for more details.

The laboratory staff is responsible for removing any hazards that Custodial Services might encounter during their activities. All chemicals, biological materials and waste containers must be moved off the floor to a safe and secure location within the laboratory before Custodial Services enters. Laboratories can make arrangements with Custodial Services by contacting x2400.

If maintenance or repair on laboratory facilities is required, a service call should be sent to x2400. Any equipment should be emptied of its contents and properly decontaminated prior to any work being performed by Facilities Operations.

In the event of laboratory decommissioning, arrangements with Custodial Services can be scheduled for floor and bench cleaning. However, it is mandatory that laboratory surfaces (counter tops, shelves, etc.) be decontaminated by laboratory staff prior to any work performed by Custodial Services.

6.2.3. Working Alone

Working alone should be avoided as much as possible. If working alone is unavoidable, the direct Supervisor must be informed and **specific** safety measures must be planned according to the University policy on working outside the hours of operation or in isolation (VPS-6).

The following are examples of safety measures that laboratory users can establish:

- Notify Security (x3717) so that a regular patrol can be planned
- Arrange for a buddy system with another laboratory user
- Organize for a regular phone check-in with a buddy or with Supervisor; if the check-in fails, they should call security

Working alone is forbidden for undergraduates.

6.2.4. Unattended Experiments

Leaving experiments unattended should be avoided as much as possible. If this is unavoidable, the direct Supervisor must be informed and safety measures must be planned according to the following guidelines:

- The Supervisor must be notified and approve the experiment;
- Ensure that all containers and equipment are labeled according to WHMIS regulations;
- Post the "Overnight Unattended Experiment" form (EHS-FORM-079) near the experiment (e.g. on fume hood sash;
- Provide for secondary containment and shielding of the material/experiment in the event of containment failure;
- Keep laboratory door window panes unobstructed.

6.2.5. Laboratory Visitors

Unauthorized visitors, including children and pets, are not permitted in laboratories. Students or colleagues from other institutions may visit laboratories as part of educational programs. However, the activity must be supervised by Concordia staff. In addition, EHS must be advised and authorization must be given by the Department or Faculty.

The Laboratory Supervisor must evaluate the risks to visitors prior to the visit, especially for visitors such as children and immune-suppressed individuals. This evaluation must be submitted to EHS.
For academic visitors, please refer to Concordia University on Academic Visitors (VPRGS-10)

6.3. Pregnant Students/Staff – New Mothers

Hazardous or radioactive products, other physical hazards and ergonomic conditions such as lifting or standing may be harmful to a pregnant employee or new mother. These must be taken into consideration.

Thus, a staff member working with or near hazardous materials should inform EHS as soon as possible after receiving confirmation of pregnancy. This information must be disclosed in order to have adjustments made to the work and the work conditions. Early disclosure is preferable as some products or work conditions may affect the pregnancy. EHS will conduct a specific risk assessment, supplementing any pre-existing one.

Pregnant staff and students are also encouraged to discuss these issues with their immediate Supervisor. Supervisors can then take the necessary precautions to remove the hazard or modify the work to accommodate the pregnancy.

If there are concerns that the work or workplace may constitute a hazard to the pregnancy, the employee/student is strongly encouraged to consult a physician. The employee/student should bring the EHS assessment, which will provide the physician with a description of the duties and the list of chemicals used in the laboratory. It is also useful to provide the material safety data sheets (MSDS) and a copy of the chemical inventory.

If the physician determines that the work or workplace is a risk to the pregnancy, the employee will be given a Preventive Withdrawal and Reassignment Certificate. EHS, Human Resources and the Supervisor **must be notified of the preventive withdrawal or reassignment**. Students can be given an exemption certificate to present to their professor or Supervisor. Pregnant employees, students and Supervisors can contact EHS to discuss occupational health risks and possible accommodations in confidence. Staff should contact Human Resources for questions regarding the Preventive Withdrawal and Reassignment Certificate and indemnities.

6.4. Transportation / Shipping of Hazardous Materials

6.4.1. Within Buildings

Hazardous products should be transported using a cart equipped with a lip or carried within a secondary container such as a chemical resistant bucket.

- **Always use a sturdy cart with a low center of gravity and spill tray**. Carts with large wheels are best to navigate irregularities in floors and over the elevator door ledge.
- **Use secondary containers to protect the primary container from shock during any sudden change of movement**. Secondary containment is important when hazardous products are transported through public areas such as hallways or elevators, where the effects of a spill would be more severe.
- **The use of the Concordia University tunnels should be avoided to move chemicals between buildings as the tunnels are used by the public to access the metro station.**
- **Freight elevators must be used for moving hazardous products between floors**. Passenger elevators must not be used for this purpose. Do not use stairways or escalators.
- Do not transport incompatible products together on the same cart unless packaged according to TDG regulations.
- All containers require a label identifying the contents in accordance with WHMIS regulation.

6.4.2. By Ground Vehicle

If a hazardous product must be transferred between buildings or campuses by means of a public road (or crossing a public road), special precautions must be taken according to the *Transportation of Dangerous Goods (TDG) Regulations*.

Unless the specified substance is exempt or present in a quantity exempt by the legislation, the following points must be observed for transportation:

- The substance is placed in an appropriate means of containment.
- The substance is clearly identified using appropriate TDG labels on the means of containment.
- The substance is properly stored and/or segregated within the transportation vehicle.
- The driver of the transportation vehicle has received TDG training.
- The transportation vehicle is properly placarded (if required).

- All the proper shipping documents are included in every step of the shipment (shipping – transport – reception).

The transportation of hazardous substances between the University's buildings and campuses should be done through Distribution Services (x2400). **Never transport hazardous substances on the University's shuttle bus**. La *Société de Transport de Montréal (STM)* also prohibits the transport of hazardous substances within buses and the metro.

For more information concerning TDG, please contact EHS at ehs@concordia.ca. You may find useful information and documentation about TDG on the EHS Laboratory Safety Programs webpage.

You may also refer to the following links from *Transport Canada* or *CANUTEC*:

- Transport of Dangerous Goods Regulation
- Canadian Transport Emergency Centre (CANUTEC)
- Transport of Dangerous Goods Safety Marks (PDF)

6.4.3. By Plane (Air Shipments)

If any shipment of hazardous materials or dangerous goods must be done by plane (air shipment), please contact EHS at ehs@concordia.ca. Air shipments must be compliant with the IATA regulations, which are different than TDG regulation requirements concerning packaging, labelling, shipping documentation, exemptions and personnel training. **Any air shipments must be verified by EHS, especially those involving shipment of biological materials on dry ice**.

7. Chemical Hazards

7.1. Workplace Hazardous Materials Information System (WHMIS 1988)

WHMIS stands for Workplace Hazardous Materials Information System. It is a comprehensive plan for providing information on the safe use of hazardous materials in Canadian workplaces. Under the legislation a hazardous material is referred to as a controlled product. A controlled product is the name given to products, materials, and substances that are regulated by WHMIS legislation.

Information is provided by means of product labels, material safety data sheets (MSDS) and worker education programs. The majority of the information requirements (and exemptions) of WHMIS legislation are under the *Hazardous Products Act* and the *Hazardous Materials Information Review Act* and apply to all of Canada. In Quebec, the CNESST is responsible for applying WHMIS according to the provincial regulations.

WHMIS 1988 was created in response to the Canadian workers' right to know about the safety and health hazards that may be associated with the materials or chemicals they use at work. As such, staff and students that work with, or may be exposed to, hazardous materials must be trained according to WHMIS legislation in the following aspects:

- Education –understanding the principles of WHMIS, and the meaning of the information on labels and MSDSs
- Training – workplace-specific training on how to apply this information to materials in actual use in the workplace, including: procedures for storage, handling, disposal, and personal protection.

Employers are responsible to ensure that everyone has been appropriately trained. At Concordia, EHS regularly offers WHMIS 1988 training, which is mandatory for all students, staff, and faculty members working with hazardous materials.

7.1.1. Product Classification

The WHMIS 1988 hazard classes for controlled products fall into one or more of six classes, where the Toxic Materials Class (Class D) is further divided into 3 subclasses (D1-D3)

Table 7.1.1 WHMIS 1988 Classification of Controlled Products

Symbol	Classes	Definition	Examples
	A Compressed gases	Products held under pressure	Argon Propane Nitrogen
	**B Flammable and combustible materials** B1 Flammable gases B2 Flammable liquids B3 Combustible liquids B4 Flammable solids B5 Flammable aerosols B6 Reactive flammable materials	Products that will burn or catch on fire easily	Propane Acetone Kerosene Magnesium Sodium Spray paint
	C Oxidizing materials	Products that can cause or promote combustion of another material (whether or not they are themselves combustible) or products that are organic peroxides	Hydrogen peroxide Nitric acid
	D1 Materials causing immediate and serious toxic effects	Products that can rapidly cause harmful health effects, including death	Carbon monoxide Phenol
	D2 Materials causing other toxic effects	Products whose health effects generally appear over time following one or several exposures	Benzene Di-isocyanates Lead
	D3 Biohazardous infectious materials	Living organisms or their toxins that can cause disease in people or animals	AIDS virus Hepatitis B virus Rabies virus

	E Corrosive materials	Products that can corrode metal surfaces or cause burns to skin	Caustic soda Hydrochloric acid Bleach
	F Dangerously reactive materials	Products that can be health or safety hazards under certain conditions (pressure, temperature, impact, violent reaction with water or air)	Fluorine Hydrogen cyanide B-Chloroprene

7.1.2. WHMIS 1988 Chemical Labels

Suppliers, employers and workers all have specified responsibilities in the *Hazardous Products Act*. When a supplier produces or imports a product for distribution and sale in Canada, that supplier must prepare a supplier label, which will typically provide seven pieces of information:

- product identification;
- hazard symbols representing the classes and divisions into which the product falls;
- risk phrases;
- precautionary statements;
- first aid measures;
- a statement advising that a material safety data sheet (MSDS) is available;
- supplier's identification.

Furthermore, **the text must be in English and French** and contained within a hatched boarder.

Supplier labels from laboratory supply houses, packaged in <10 kilogram quantities, and intended for laboratory use, must have:

- product identifier
- risk phrases
- precautionary measures
- first aid measures
- reference to availability of MSDS

Workplace labels are required on containers of controlled products produced on site and on containers in which the product has been transferred from a supplier's container. Workplace labels must provide three types of information:

- product name
- safe handling information
- reference to the MSDS

In Quebec, the minimal language requirement for workplace labels is French. However, English is the minimum language requirement at Concordia University since it represents the teaching/working language used for daily research activities. Hazard symbols and the use of the hatch-mark border are optional. A sample workplace label is shown below.

At Concordia, all containers holding hazardous material must be labelled with a workplace label. In addition, if the controlled product is transferred to piping systems, reaction vessels, etc., the employer must ensure the system is properly identified as to its content. Workers must be instructed regarding the information contained on labels and identifiers.

The employer must take steps to ensure labels are not defaced and are easy to read at all times.

Table 7.1.2-1: WHMIS Labeling Requirements

WHMIS Labelling Requirements	Workplace	Supplier			
	For immediate use products	Standard product < 100 ml	Standard product ≥ 100ml	Less than 10 kg AND from supply house	Less than 10 kg and sample from a laboratory
Product identifier	Required	Required	Required	Required	Required
Supplier identifier		Required	Required		Required
Risk phrase			Required	Required	
Precautionary measures	Required		Required	Required	
MSDS reference	Required	Required	Required	Required	
First Aid			Required	Required	
Hazardous ingredient disclosure					Required
Emergency phone number					Required
Hazard symbols		Required	Required		
Hatched border		Required	Required		Required
"Hazardous Lab Sample" statement					Required

7.1.3. Material Safety Data Sheet (MSDS)

Additional information about a controlled product is provided on its Material Safety Data Sheet (MSDS). They are provided by the supplier to give users detailed information about the hazards and safe use of products. Before using any product for the first time, students and staff should review the MSDS for information.

The information on the MSDS is divided into nine sections:

1) product information;
2) hazardous ingredients;
3) physical data;
4) fire and explosion hazard;
5) reactivity data;
6) toxicological properties (health effects);
7) preventive measures;
8) first aid measures;

9) preparation information

No MSDS may be more than three years old.

Most suppliers have adopted a new format, following the WHMIS 2015 requirements. Under WHMIS 2015, Safety Data Sheets (SDSs) contain 16 sections rather than the 9 required by WHMIS 1988.

For more information about WHMIS, please refer to the following links:

- WHMIS - Official National Site - Health Canada
- CNESST - Quebec

7.2. WHMIS 2015

7.2.1. Summary

The ***Globally Harmonized System of Classification and Labelling of Chemicals (GHS)*** was adopted by the UN Economic and Social Council (ECOSOC) in July 2003. The purpose of this system is to regroup all existing hazard communication systems on chemicals in order to develop a single, globally harmonized system to address classification of chemicals according to their hazards and communicate the related information through labels and safety data sheets.

On February 11, 2015, the Government of Canada published the Hazardous Products Regulations (HPR, SOR/2015-17), repealing at the same time the former *Controlled Products Regulations (SOR/2015-17, s. 21)*. The new HPR modified the Workplace Hazardous Materials Information System (WHMIS) 1988 to incorporate the *Globally Harmonized System of Classification and Labelling of Chemicals (GHS)* for workplace chemicals. This modified WHMIS is referred to as **WHMIS 2015**.

Even though the GHS system is now ready for worldwide implementation, many countries including Canada are only beginning the task of harmonizing existing regulatory regimes within the GHS framework. In order to give suppliers, employers and workers time to adjust to the new system, implementation of WHMIS 2015 will take place over a three-stage transition period that is synchronized nationally across federal, provincial and territorial jurisdictions. During the different transition phases proposed, both WHMIS 1988 and WHMIS 2015 versions can be used. More details concerning the different WHMIS transition phases can be obtained from Health Canada WHMIS Transition web page.

7.2.2. WHMIS 2015 Classification

The new WHMIS 2015 legislation proposes new classification rules and hazard classes based on physical and health hazards. The environmental hazards proposed by GHS have not been retained under the new WHMIS 2015 legislation, even though suppliers are free to identify them on their products. Hazard groups are also divided into hazard classes, which are further divided into categories and subcategories.

Table 7.2.2-1: WHMIS 2015 Physical Hazard Classes

Physical Hazard Classes	
Flammable gases	Substances and mixtures which, in contact with water, emit flammable gases
Flammable aerosols	Self-reactive substances and mixtures
Flammable liquids	Self-heating substances and mixtures
Flammable solids	Gases under pressure
Oxidizing gases	Corrosive to metals
Oxidizing liquids	Organic peroxides
Oxidizing solids	Simple asphyxiants
Pyrophoric gases	Combustible dusts
Pyrophoric liquids	Physical hazards not otherwise classified (PHNOC)
Pyrophoric solids	

Table 7.2.2-2: WHMIS 2015 Health Hazard Classes

Health Hazard Classes	
Acute Toxicity	Reproductive Toxicity
Skin corrosion/irritation	Specific Target Organ Toxicity – Repeated Exposure
Serious Eye Damage/Eye Irritation	Specific Target Organ Toxicity – Single Exposure
Respiratory or Skin Sensitization	Aspiration Hazard
Germ Cell Mutagenicity	Biohazardous Infectious Materials
Carcinogenicity	Health Hazards Not Otherwise Classified

7.2.3. Supplier Label Requirements

Most of the WHMIS 2015 supplier label elements will be standardized and the information must be easily legible without the aid of any device other than corrective lenses. Each hazard class and category has a prescribed:

- Signal word;
- Hazard statements (H phrases);
- Precautionary statements (P phrases);
- Hazard pictogram(s).

The signal word indicates the severity of the hazard:

- ***Danger***: for more severe hazards;
- ***Warning***: for less severe hazards.

Only one signal word must appear on the label. Some low hazard categories may not have a signal word assigned.

Hazard statements are brief standardized sentences that describe the hazards of the product. The wording of the hazard statement helps describing the degree of the hazard. Some examples of hazard statements include:

- *Extremely flammable gas;*

- *Contains gas under pressure; may explode if heated;*
- *Fatal if inhaled;*
- *Causes eye irritation;*
- *May cause cancer.*

Precautionary statements provide standardized advice on how to minimize or prevent harmful effects from the product. They give instructions about storage, use, first aid, PPE and emergency measures. Some examples of precautionary statements include:

- *Keep container tightly closed;*
- *Wear protective gloves / protective clothing / eye protection / face protection;*
- *If exposed or concerned: get medical advice/attention;*
- *Fight fire remotely due to risk of explosion;*
- *Protect from sunlight.*

The following information will be required on WHMIS 2015 supplier labels:

1. Product identifier
2. New hazard pictograms
3. Signal word
4. Hazard statements
5. Precautionary statements
6. Initial supplier identification

Figure 7.2.3-1: WHMIS 2015 supplier label

The information on labels still needs to be in English and French. However, the presence of the following items on the supplier labels is not required anymore:

- a hatched border;
- a statement that a MSDS (or SDS) is available.

7.2.4. Hazard Pictograms

The following table shows the new WHMIS 2015 pictograms associated with the different hazard classes.

Table 7.2.4-1: WHMIS 2015 Hazard Pictograms and Classes

Pictogram	Hazard Classes
	Explosives* Self-reactive substances and mixtures Organic peroxides
	Flammables (gases, aerosols, liquids, solids) Self-reactive substances and mixtures Pyrophoric liquids, solids and gases Self-heating substances and mixtures Substances and mixtures, which, in contact with water emits flammable gas Organic peroxides
	Oxidizing gases, liquids and solids
	Gases under pressure
	Serious eye damage Skin corrosion Corrosive to metals
	Acute toxicity (severe)
	Skin sensitization Skin irritation Eye irritation Acute Toxicity (harmful) Specific target organ toxicity – single exposure (Category 3) Hazardous to the ozone layer*
	Carcinogenicity Respiratory sensitization Reproductive toxicity Specific target organ toxicity – repeated exposure Specific target organ toxicity – single exposure (Categories 1 & 2) Germ cell mutagenicity Aspiration hazard
	Hazardous to the aquatic environment*
	Biohazardous infectious materials

**The environmental hazards classes and the explosives hazard class are not proposed for adoption in Canada.*

7.2.5. Safety Data Sheet (SDS)

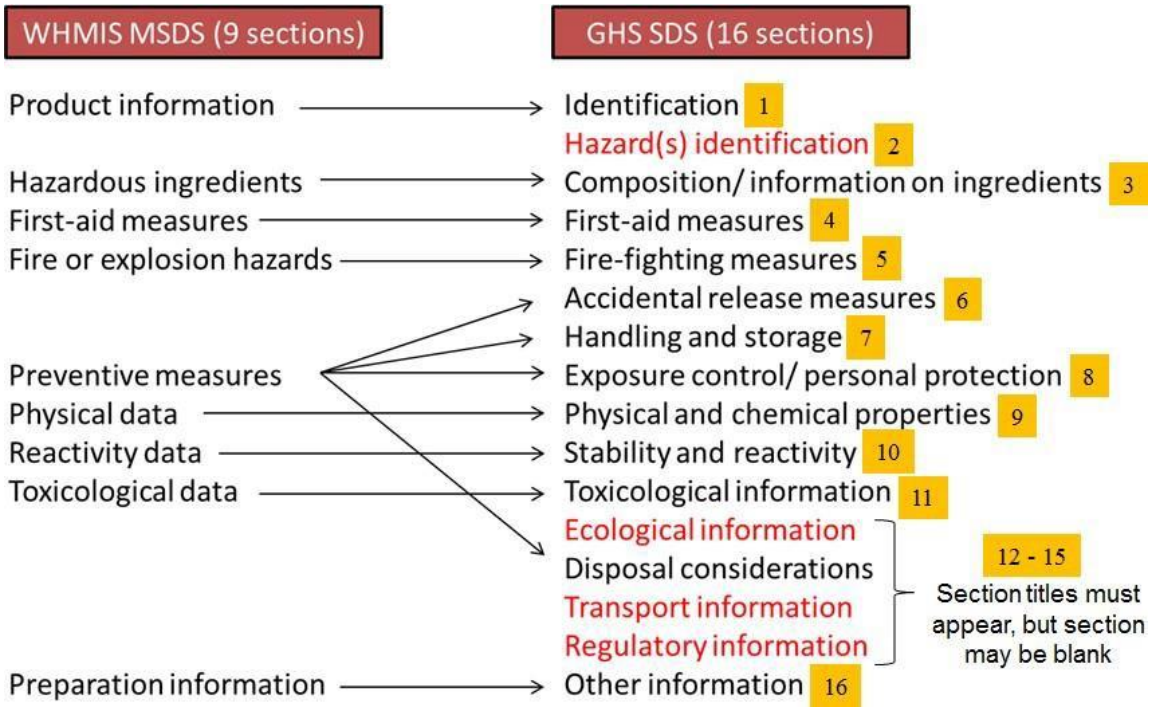
Safety Data Sheets (SDSs) are replacing Material Safety Data Sheets (MSDS). They have a new format of 16 standardized headings and must be available for every hazardous product in the workplace covered by WHMIS.

Safety Data Sheets (SDSs) provide employers and workers with comprehensive information about chemical products. This information can be used in the workplace to identify the hazards and assess the risks of using the chemical product.

The following figure maps the similarities and differences between the WHMIS 1988 MSDS and WHMIS 2015 (GHS format) SDS. The section numbers are highlighted in yellow, while new sections are highlighted in red. It has to be noticed that, under WHMIS 2015, information in sections 12 to 15 are not required to be displayed.

Suppliers must still provide SDSs in English and French in Canada. However, under WHMIS 2015, the 3 year SDS review period requirement has been removed in Quebec as the SDS must be accurate at each time of sale or importation.

Figure 7.2.5-1: WHMIS 1998 and WHMIS 2015 SDS Comparison



For more information about WHMIS 2015, please refer to the following links:

WHMIS 2015 - Health Canada
WHMIS.ORG

7.3. Working with Hazardous Chemicals

In order to prevent harmful health effects, hazards must be eliminated, reduced or controlled. Such control methods include:

- Elimination of the danger at the source
- Substitution with a less hazardous material or industrial process.
- Engineering controls: use of ventilation, encapsulation or other means to limit exposure.
- Administrative controls: training, restricted access, SOPs…
- Wearing proper PPE: gloves, laboratories coat, safety glasses, respirators…

7.3.1. Very Toxic and Toxic Materials

Very toxic and toxic materials cause serious health effects by damaging critical body systems. These body systems include the lungs, nervous system, oxygen transport in the blood and kidneys. **The exposure may be acute (immediate effect or within short timeframe), or may be chronic (delayed effect)**. For example, the signs and symptoms of lung injury may not appear until 24-48 hours after exposure. Always consult a product's MSDS to identify its target organ(s). This information is even more essential for people with pre-existing conditions.

i. Mercury

Even though the use of metallic mercury at the University is not prohibited, EHS strongly suggests minimizing its usage and replacing it with less hazardous alternatives. Mercury causes health hazards and has been recognized as an environmental contaminant by several public organisms (*Health Canada, Environment Canada, Institut national de santé publique du Québec*). Furthermore, in the event of a mercury spill, special cleaning procedures must be taken.

Old laboratory equipment using thermometers, barometers, manometers or other measuring instrumentation are likely to contain mercury. However, it is now possible to obtain scientific equipment where mercury has been replaced with safer and greener alternatives without compromising the measurements' quality and precision. Non-mercury thermometers contain about 0.15mL of different colored organic liquids (kerosene, acetone, alcohol or vegetable oil) which make them less hazardous in the event of a spill. Therefore, a broken non-mercury thermometer can be thrown directly into a puncture-proof chemical waste container.

EHS can provide lab-grade replacement thermometers with temperature ranges from -20°C to 250°C and from -10°C to 260°C. If you have any mercury thermometers in your possession and wish to exchange them, please contact EHS at hazardouswaste@concordia.ca, mentioning how many thermometers you wish to exchange. Please note this program is based on a 1 to 1 exchange; EHS will distribute replacement thermometers only to labs that provide mercury thermometers in exchange

Electronic thermometers can also represent interesting alternatives to mercury. They can measure temperatures from -50°C to 300°C. However, most thermometers with mercury replacement (liquid or electronic) cannot measure temperatures above 300°C. Therefore other alternatives, such as thermocouples, should be considered.

Mercury Safety Guidelines are available from the EHS website[5].

If thermometers or other equipment containing mercury are to be discarded, contact EHS at hazardouswaste@concordia.ca for a pickup.

ii. Hydrogen Fluoride (HF)

Hydrogen fluoride (HF) or hydrofluoric acid is an extremely corrosive substance and is significantly more hazardous than any other acid.

HF is a contact poison; contact may not be noticed until long after serious damage has been done. HF can cause serious burns to the skin with significant complications due to the fluoride toxicity. Deaths have been reported from concentrated hydrofluoric acid burns involving as little as 2.5% body surface area (BSA), an area roughly the size of the hand.

All laboratory users handling HF must:

- Follow safe work practices specified by the SOP or the Supervisor.
- Wear appropriate PPE.
- Have access to a working emergency shower/eyewash station.
- Have access to calcium gluconate gel. **Calcium gluconate gel must be replaced before its expiration date**.

Hydrogen Fluoride Safety Guidelines are available from the EHS website.[6]

7.3.2. Carcinogens, Mutagens, Teratogens and Reproductive Toxins

Carcinogens, mutagens, teratogens and reproductive toxins can cause serious health problems (e.g. cancer, birth defects, sterility and genetic mutations) in workers and/or their unborn children. There may be no early warning signs of the harmful, and possibly irreversible, effects that may occur long after exposure. Thus they are regarded as especially hazardous products. New and Expectant Mothers are strongly encouraged to contact EHS as soon as possible, especially when working with these chemicals.

- ***Carcinogens*** are identified by their ability to cause cancer in humans or animals. Many occupational cancers have a long latency period, meaning that cancer may develop 10–20 years or longer after exposure to the carcinogen.

- ***Mutagens*** can cause changes (mutations) in the genetic material (DNA) of cells which may result in disease or abnormalities in future generations. In WHMIS, mutagens are classified as very toxic if they are shown to affect cells of the reproductive system. Mutagens are classified as toxic if studies show genetic changes only in cells (e.g. skin or lung cells) that are not part of the reproductive system.

- ***Teratogens and embryotoxins*** can cause birth defects, abnormalities, developmental delays, or death in developing offspring in the absence of significant harmful effect on the mother.

[5] http://www.concordia.ca/content/dam/concordia/services/safety/docs/EHS-DOC-112_MercuryGuidelines.pdf
[6] http://www.concordia.ca/content/dam/concordia/services/safety/docs/EHS-DOC-008_HFguidelines.pdf

- ***Reproductive toxins*** can cause sterility or reduced fertility in offspring, or other adverse reproductive effects (e.g. the mother's ability to produce milk).

7.3.3. Sensitizers

Sensitizers are materials that can cause severe skin and/or respiratory responses in a worker after exposure to a very small amount of the material. Sensitization develops over time. When a worker is first exposed to a sensitizer, there may be no obvious reaction. However, future exposures can lead to increasingly severe reactions in sensitized workers. Not all exposed workers will react to sensitizing materials. Some workers will never become sensitized.

- *Skin sensitization* - skin sensitizers can cause an allergic reaction, with redness, rash, itching, swelling or blisters at the point of contact or elsewhere in the body.

- *Respiratory sensitization* - respiratory sensitizers can at first cause symptoms similar to a cold or mild hay fever. However, eventually severe asthmatic symptoms can develop in sensitized workers, including wheezing, chest tightness, shortness of breath, difficulty breathing and/or coughing. A severe asthmatic attack can cause death.

7.3.4. Working Safely with Chemicals

In order to work safely with toxic products, one must:

- **Consult the Safety Data Sheet** (SDS) for information about the hazards and the necessary precautions for handling the material being used.
- **Understand all of the hazards** associated with the material, including additional health concerns (e.g. serious short-term health effects or irritation), reactivity and flammability.
- Know **how to use** the chemicals safely.
- Ensure **engineering controls** (e.g. ventilation, fume hoods) are operating. Closed handling systems (glove box) may be necessary to prevent the release of the material (dust, mist, vapor, gas) into the workplace.
- Use the smallest quantity possible and use only in well-ventilated areas.
- Follow safe work practices specified by the SOP or the Supervisor.
- Wear the appropriate personal protective equipment specified for the work. This may include respiratory protection and chemical protective clothing, such as an apron and gloves, made from materials that protect against the chemicals handled.
- Report ventilation failures to the service call centre immediately, at x2400.
- Report all leaks, spills, incidents and injuries to Security immediately, at x3717.
- Keep Supervisor informed of all reported issues.
- Understand and practice emergency procedures to know what to do in case of a spill or other emergency.
- Wash hands thoroughly after handling and before leaving the laboratory.

7.4. Chemical Storage

7.4.1. General Guidelines

SDSs contain general recommendations for the safe storage of a hazardous product. These recommendations provide a good starting point for deciding where and how the product should be stored. The storage conditions in the workplace should be based on workplace specific factors: the hazards of the product (health, fire and reactivity), the amount in storage, types of containment (bulk or smaller containers), and the way the product is used. Use chemically-resistant structural materials in the storage area and ventilation system (e.g. corrosion-resistant).

The following guidelines should be used when storing any chemical:

- Ensure that all containers are in good condition and are properly labelled.
- Use approved containers being aware of any special ventilation requirements (e.g. for flammables, corrosives).
- Do not store incompatible materials together. Dangerous combinations include:
  - Acids + Bases
  - Flammables + Oxidizers
  - Water Reactives + Aqueous Solutions
- **Segregate corrosives from flammables.**
- **Segregate strong oxidizers from everything.**
- **Most organic reactives must be segregated from inorganic reactives (metals).**
- **Segregate reactives from flammables.**
- Do not store chemicals in alphabetical order, except within a grouping of compatible chemicals.
- Use secondary containment trays to contain potential spills.
- Maintain good housekeeping practices and minimize clutter.
- Ensure appropriate spill control and fire protection equipment is readily available in or near the storage area.
- Liquid chemicals should be placed below eye level.
- Flammable liquids should be stored in approved flammable safety cabinets, spark-proof fridges or freezers.
- All chemicals in a laboratory should have a definite storage place and should be returned to that location after being used.
- Chemicals should never be stored on the floor or in the fume hood, unless the hood is dedicated for that purpose.
- All containers must have caps and covers that are securely in place whenever the container is not in use.
- Avoid storing chemicals on bench tops, except for those chemicals in use or non-hazardous dry chemicals, such as salts (e.g. sodium chloride, potassium chloride), filtering media (e.g. Celite, silica, sand) or drying agents (e.g. magnesium sulfate).

7.4.2. Compatibility

Incompatible chemicals are those that if mixed, would produce toxic gases, explosive reactions, or spontaneous ignition. Such chemicals should never be stored or handled in a manner that might allow contact.

Table 7.4.2-1 is a chart adapted from the CRC Laboratory Handbook which groups various chemicals into 24 different groups with examples and incompatible chemical groups. This chart is by no means complete but it will aid in making decisions about storage.

Table 7.4.2-1: Chemical Group Compatibility for Safe Storage

Chemical Group	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24
1. Inorganic Acids		X	X	X	X	X	X	X		X	X		X	X		X	X	X	X		X	X		X
2. Organic Acids	X		X	X			X							X		X	X	X	X			X		X
3. Caustics	X	X			X		X	X					X	X	X	X	X	X		X		X		X
4. Amines	X	X			X		X	X			X		X	X	X	X	X	X						X
5. Halogenated Compounds	X		X	X										X			X							
6. Alcohols and Glycols	X						X							X		X								X
7. Aldehydes	X	X	X	X		X		X							X	X	X		X	X				X
8. Ketones	X		X	X			X												X	X				
9. Saturated Hydrocarbons																				X			X	
10. Aromatic Hydrocarbons	X																			X			X	
11. Olefins	X			X																X			X	
12. Petroleum Oils																				X			X	
13. Esters	X		X	X															X	X				
14. Polymerizable Compounds	X	X	X	X	X	X									X	X			X	X	X			X
15. Phenols			X	X			X							X		X			X	X				
16. Alkylene Oxides	X	X	X	X		X	X							X	X		X	X	X				X	X
17. Cyanohydrins	X	X	X	X	X		X									X			X					X
18. Nitriles	X	X	X	X												X								X
19. Ammonia	X	X					X	X					X	X	X	X	X			X				X
20. Halogens			X			X	X	X	X	X	X	X	X	X	X				X		X	X		
21. Ethers	X													X						X				
22. Phosphorus	X	X	X																	X			X	
23. Sulfur (molten)									X	X	X	X				X						X		
24. Acid Anhydrides	X		X	X		X	X							X		X	X	X	X					

X — Unsafe storage combination

Safe storage combination

A more detailed segregation Table can be found in the **APPENDIX II. An EHS on-line seminar concerning hazardous material storage is also available. Please consult the Chemical Safety Program web page for more details.**

7.4.3. Storage of Flammable Materials

The use and storage of flammable and combustible liquids may be necessary for some research laboratory operations. Flammable liquids are defined as liquids with a flash point below 38°C and a vapor pressure that does not exceed 40 psi at 38°C. Flammable liquids are subdivided as follows:

Table 7.4.3-1: Flammable Liquids Classification

Flammable Liquid Class	Definition	Examples
IA	Liquids with flash points below 23°C and boiling points below 38°C	Diethyl ether, n-Pentane, Acetaldehyde
IB	Liquids with flash points below 23°C and boiling points at or above 38°C	Acetone, Acetonitrile Ethanol (>50% if aqueous)
IC	Liquids with flash points at or above 23°C and below 38°C	Isopropyl alcohol Turpentine, Xylenes

Combustible Liquids are liquids with a flash point above 38°C. Combustible liquids are subdivided as follows:

Table 7.4.3-2: Combustible Liquids Classification

Combustible Liquid Class	Definition	Examples
II	Liquids with flash points at or above 38°C and below 60°C	Acetic acid, Kerosene
IIIA	Liquids with flash points at or above 60°C and below 93°C	Ethanolamine, DMSO, Aniline
IIIB	Liquids with flash points above 93°C	Ethylene glycol, Benzyl alcohol

The National Fire Code of Canada sets limits on the use and storage of flammable and combustible liquids. It mentions that the quantity of dangerous goods stored in a research laboratory must be restricted to the minimum amount required for normal operation or to 300L of flammable and combustible liquids, including a maximum limit of 50L for flammable liquids class I.

Any quantities of flammable and combustible liquids exceeding those limits must be stored into a flammable storage cabinet while respecting the storage limits of the particular flammable storage cabinet used. Any amounts of flammable or combustible liquids exceeding this amount must be stored outside the laboratory in an approved flammable storage area.

Furthermore, the National Fire Code of Canada also limits the total amount of flammable liquids located in the basement of a building to 5L.

i. Flammable Storage Cabinet

Flammable Cabinets must meet the construction specifications of the National Fire Protection Association (NFPA), Flammable and Combustible Liquids Code, NFPA 30. The purpose of a flammable storage cabinet is to prevent the contents from catching fire or exploding for at least 10 minutes in case of fire, in order to give personnel a chance to escape. A flammable storage cabinet may be required depending upon:

- The class of flammable or combustible liquid
- The total quantity of flammable or combustible liquid
- The location of the flammable or combustible liquid

According to NFPA 30, it is not a requirement for flammable storage cabinet to be ventilated. Doing so could reduce the cabinet's fire protection effectiveness. If not vented, the vent openings must be sealed by a fireproof material of equivalent fire protection grade (for example, the bungs provided by the cabinet manufacturer).

However, if researchers choose to vent their cabinets in order to reduce odorous vapors, the following criteria must be followed:

- Mechanical exhaust ventilation must be utilized. Exhaust must be discharged above the roof using an existing laboratories exhaust system or an independent system.
- The cabinet must be vented from the bottom with fresh air being supplied from the top. The flame arrestor must remain in both the lower and upper bung holes. The bung holes should be regularly inspected and cleaned to prevent them from becoming blocked.
- The exhaust duct provided must be a material of equivalent fire resistance (or better) as the material used for the cabinet's construction. The exhaust duct must also be a material compatible with the liquids stored inside the cabinet.
- The use of stove pipe, dryer vent and regular PVC is prohibited.

Other considerations concerning flammable storage cabinets:

- Flammable storage cabinets should never be located by exit doors.
- Flammable storage cabinets must be listed by Factory Mutual, Underwriter's Laboratory or other qualified testing agencies.
- Materials stored within flammable storage cabinets should be compatible with the cabinet's design and construction.
- Grounding is not required unless Class IA flammable liquids are being dispensed from the cabinet.
- Flammable storage cabinets must be clearly labeled with a sign that reads: "Flammable – Keep Fire Away".
- Flammable storage cabinets are not design to store flammable compressed gases.
- Flammable storage cabinets should not be used to store corrosives, as they may corrode the cabinet and are incompatible with organic solvents.

7.5. Peroxide Forming Solvents and Reagents

Solvents and reagents that can form hazardous peroxides should be labeled upon arrival with the date received and the expiration date. They must be disposed of before the expiration date to avoid any safety hazards.

Containers of peroxide forming solvents/reagents should be periodically inspected. **Avoid contact if there are signs of crystallization of the chemical. Contact Security immediately at x3717.**

Peroxide forming solvents and reagents are divided into 3 categories, of which class 1 is the least dangerous and class 3 is highly dangerous.

Table 7.5-1: The Classes of Peroxide-Forming Solvents

Class III	Class II	Class I
Explosive levels of peroxides are formed without a concentration step, e.g., evaporation, distillation, etc. These chemicals can be a particular hazard since peroxides can form even without opening the containers. Therefore, only small amounts should be ordered and used as soon as possible. If stabilizers are present in solution, they can be kept for up to one year or up to the manufacturer's expiration date where appropriate. With no stabilizer present, they should not be kept for over three months after opening. When possible, store these chemicals under a nitrogen blanket.	Explosive levels of peroxides are formed upon concentration. These chemicals typically accumulate hazardous levels of peroxides when evaporated, distilled, contaminated, or have their peroxide inhibiting compounds compromised. After receiving, they should not be kept past 12 months or the manufacturer's expiration date. After this period, the product must be disposed.	They may auto polymerize as a result of peroxide accumulation. They can undergo hazardous polymerization reactions that are initiated by peroxides that have accumulated in solution. They are typically stored with polymerization inhibitors to prevent these dangerous reactions. Inhibitors do become compromised over time however, and thus these chemicals should not be kept for over 12 months after reception or the manufacturer's expiration date. Non-inhibited chemicals should not be opened and stored over 24 hours. Non-inhibited chemicals should be inhibited with the appropriate compounds before the 24-hour mark is exceeded.

For detailed information and list of some common used chemicals, please refer to Appendix III: Peroxide forming chemicals and solvents.

7.6. Compressed Gases Safety

A compressed gas is a substance that is a gas at normal room temperature and pressure, and is contained under pressure, usually in a cylinder. Some compressed gases (e.g. acetylene) are stabilized in the cylinder by dissolving the gas in a liquid or solid matrix.

Compressed and liquefied gases are routinely used in laboratories and various other operations at Concordia University. They have the potential for creating hazardous working environments. Complete guidelines concerning the use of compressed gas can be found in the **Compressed Gas Safety Manual**, and also within the following NFPA codes and standards:

- NFPA 45 Standards on Fire Protection for Laboratories Using Chemicals
- NFPA 55 Compressed Gases and Cryogenic Fluids Code
- NFPA 58 Liquefied Petroleum Gas Code
- National Fire Code of Canada 2015 (including Quebec modifications)

Always contact EHS for a hazard assessment prior to any cylinder set-up.

7.6.1. Handling Requirements

- Obtain proper training and information before using a gas cylinder.
- Never drag or physically carry cylinders (lecture cylinders may be carried).
- Never lift cylinders by the cap.
- Do not drop or bang cylinders against each other.
- Use a hand cart designed for the transport of cylinders.
- Secure cylinder caps during transport.
- Leave the cylinder cap in place until the cylinder is secured and ready for use.
- Do not rely on cylinder colour to identify the gas. Different suppliers may use different colours for cylinders of the same gas.
- Only transfer cylinders or cryogenic liquid containers across buildings using Distribution Services.

7.6.2. Cylinder Set-Up

- Contact EHS prior to any cylinder set-up.
- Secure cylinders to a wall, a cylinder-rack or an appropriate bench in an upright position, using a chain or a cylinder belt (wires are not acceptable) above the midpoint, but below the shoulder.
- Cylinders in the laboratory shall be equipped with a pressure regulator designed for the specific gas and marked for its maximum cylinder pressure.
- Never use homemade adaptors or force connections between cylinder valve and gas handling equipment.
- Do not apply any lubricant, jointing compound or tape to cylinder valves, fittings or regulator threads unless specified by the manufacturer.
- The regulator system shall be equipped with two gauges to show both the cylinder pressure and the outlet pressure.
- Where the source cylinder is outside of the laboratory, a station regulator and gauge shall be installed at the point of use to show outlet pressure.
- Cylinders shall have a manual shutoff valve.

7.6.3. Storage Guidelines

Store gas cylinders:

- In an upright position.
- Within a well-ventilated area.
- Separated from empty cylinders.
- With a chain or appropriate belt above the midpoint, but below the shoulder. Laboratory cylinders less than 18 inches tall may be secured by approved stands or wall brackets.
- Away from corrosive chemicals.
- Away from direct sunlight or heat sources.
- Capped when not in use.
- At least 20 feet away from all flammable, combustible or incompatible substances.

Storage areas that have a non-combustible wall at least 5 feet in height and with a fire resistance rating of at least 30 minutes may be used to segregate gases of different hazard classes in close proximity to each other.

Do not store gas cylinders:

- In exits or egress routes or at less than 1m from an exit
- In damp areas, near salt, corrosive chemicals, fumes, heat or exposed to the weather without roof housing.
- Longer than one year without use.

7.6.4. Cylinders in Use

Cylinders, when in use, shall be connected to gas delivery systems designed by a qualified person. A compressed gas cylinder shall be considered to be "in use" if it is in compliance with one of the following:

- Connected through a regulator to deliver gas to a laboratory operation
- Connected to a manifold being used to deliver gas to a laboratory operation
- A single cylinder secured alongside a cylinder connected to gas delivery system which serves as the reserve cylinder for that system.

Cylinders not "in use" shall not be stored in the laboratory unit.

7.6.5. Storage Limits for Hazardous Gases

According to NFPA 55, the amount of hazardous compressed gases permissible within a Laboratory Work Area is outlined in the table 7.6.5-1.

Table 7.6.5-1: Maximum Allowable Quantities (MAQ) for Hazardous Gases

	Flammable Gas Compressed (e.g. Hydrogen, Methane)	Oxidizing Gas Compressed (e.g. Oxygen)	Toxic Gas Compressed (e.g. Carbon Monoxide)
Amount Allowed per 500 ft^2 of Laboratory Work Area	6 cu ft. internal cylinder volume	6 cu ft. internal cylinder volume	0.3 cu ft. internal cylinder volume
Maximum Number of standard cylinders	4 cylinders (9"x51" cylinder)	4 cylinders (9"x51" cylinder)	1 lecture bottle
Lecture Bottle Limits	In addition to the maximum internal volumes above, the total number of lecture bottle cylinders shall be limited to 25 per Laboratory Work Area.		

Furthermore, there are no limits set for storage of non-flammable, inert gases (e.g. argon, nitrogen).

7.6.6. Special Ventilation Requirements

i. Toxic Gases

This section shall not apply to gases that have a health rating of 3, as rated in NFPA 704, if they are rated as such by virtue of it being a cryogen, with no other health hazards.

Lecture bottle-sized cylinders of the following gases located in laboratory units shall be kept in a continuously mechanically ventilated enclosure:

- All gases that have health hazard rating of 3 or 4
- All gases that have a health hazard rating of 2 without physiological warning properties

- Pyrophoric gases (e.g. silane)

Cylinders of all gases that are greater than lecture bottle size and have health hazard ratings of 3 or 4 and cylinders of gases that have a health hazard rating of 2 without physiological warning properties that are located in laboratory units shall meet both the following conditions:

- Storage in approved continuously mechanically ventilated gas cabinets.
- Compliance with NFPA 45 and NFPA 55

Cylinders of pyrophoric gases that are greater than lecture bottle size that are located in laboratory units shall be kept in approved continuously mechanically ventilated, sprinklered gas cabinets.

Common toxic or highly toxic gases are listed in **Appendix IV: [Flammable or Toxic] Compressed and Liquefied Gases**.

ii. Flammable Gases

As for toxic gases, **EHS strongly recommends** that flammable gas cylinders rated 4 under NFPA 704 that are greater than a lecture bottle size should be placed into approved continuously mechanically ventilated gas cabinets.

7.6.7. Asphyxiation – Carbon dioxide

Carbon dioxide is primarily an asphyxiant but also has mild toxic properties. The recommended exposure limits for carbon dioxide are:

- 5,000 ppm (0.5%) by volume - calculated as an 8h time-weighted average concentration in air.
- 15,000 ppm (1.5%) for a 15 minute period.

For these reasons, a carbon dioxide monitor should be used when there is a risk of CO_2 exposure, rather than an oxygen deficiency monitor.

Table 7.6.7-1: Carbon dioxide exposure symptoms

Carbon dioxide content (%vol)	Effects and symptoms
2-4	Slight feeling of suffocation and an increased breathing rate
5	Headaches, dizziness and sweating can occur after 30 minute exposure
5-9	Breathing becomes laboured, judgement impaired
5-9	Breathing becomes laboured, judgement impaired
9	Fatal after approximately four hours exposure
12	Immediate unconsciousness; fatality may occur after a few minutes

7.7. Cryogenic Gases

There are particular hazards and risks associated with working with cryogenic gases. Users should assess the risks and take suitable precautions for their personal safety and the safety of those around them. Here are some cryogens found at the University:

- Liquid Helium: -269°C
- Liquid Nitrogen: -196°C
- Liquid Argon: -186°C

- Liquid Oxygen: -183°C
- Solid Carbon Dioxide (Dry Ice): -78°C

The main hazards arising from the use of low-temperature liquefied gases are:

- asphyxiation in oxygen-deficient atmospheres
- cold burns, frostbite and hypothermia from the intense cold
- fire in oxygen-enriched atmospheres
- liquid oxygen condensation
- over pressurization from the large volume expansion of the liquid
- failure or tampering of pressure relief valves

7.7.1. Cold Burns, Frostbite and Hypothermia

Contact with extremely cold surfaces can cause cold burns and frostbite. Low air temperatures can also cause hypothermia or provoke asthma. It is essential that protective clothing (such as cryogenic gloves and goggles) is worn where there is a risk of contact with the cryogenic liquid or cryogenically-cooled materials. Avoid direct skin contact with cryogenic liquids or compressed gases escaping from the cylinder.

7.7.2. Asphyxiation – Liquid Nitrogen, Argon and Helium

Releasing liquid nitrogen, argon or helium may produce local oxygen-deficient atmospheres, which will result in asphyxiation. Release may be caused by a leak, a spill, or simply during the process in which the gas is used. Oxygen deficiency monitors shall be used whenever the risk of asphyxiation is present.

Table 7.7.2-1: Oxygen deficiency symptoms

Oxygen content (%vol)	Effects and symptoms (at atmospheric pressure)
11-14	Diminution of physical and intellectual performance without person's knowledge
8-11	Possibility of fainting after a short period without prior warning
6-8	Fainting within a few minutes, resuscitation possible if carried out immediately
0-6	Fainting almost immediate, death ensues, brain damage if rescued

7.7.3. Fire Hazards from Oxygen-Enriched Atmosphere

If the atmosphere is enriched with oxygen, the potential likelihood and intensity of fire are increased. Many materials which are not usually combustible in air will burn fiercely in an oxygen-enriched atmosphere. The required energy to ignite these materials will be reduced: the higher the oxygen concentration in the air, the lower ignition energy required. These materials can be ignited with a level of energy that would not be considered sufficient in normal atmospheric air. Some materials may auto-ignite in oxygen-rich atmospheres.

7.7.4. Liquid Oxygen Condensation

Liquid nitrogen and helium are cold enough to condense oxygen from the air, leading to a risk of combustion. Vessels should be insulated to minimize this risk. It is recommended to exclude combustible materials.

7.7.5. Over Pressurization

Cryogenic systems must be designed with adequate pressure relief measures such as valves. This prevents a dangerous build-up of pressure as the liquid condenses into a gas in a sealed system. Vessels and piping shall sustain at least 150 percent of maximum pressure relief.

Cryogens Guidelines can be found on the EHS website.

7.8. Liquefied Petroleum Gases (LPG)

7.8.1. Definition and Associated Hazards

A liquefied petroleum gas (LPG) is a flammable mixture of hydrocarbon gases (butane, iso-butane, propane, propylene, butylene and other hydrocarbons of low molecular weight refined from petroleum) within a pressurized container which exists both as a liquid and a gas at 20°C (68°F). LPGs are mainly used as a fuel in heating appliances and vehicles.

It is important not to store LPG cylinders inside flammable liquid storage cabinets. Storage and usage of LPG is covered in NFPA 58, *Liquefied Petroleum Gas Code*, while storage of flammable liquids is covered in NFPA 30, *Flammable and Combustible Liquids Code*.

LPGs are not flammable liquids; they are flammable liquefied gases.

This distinction is very important. Flammable liquids and flammable gases have different storage conditions. A flammable liquid storage cabinet is designed to protect flammable liquid containers from fire for 10 minutes to allow for safe evacuation. **LPGs usage is severely restricted in buildings because of their rapid evolution of gas from leaks**, which are orders of magnitude greater than the evolution of vapours from flammable liquids.

LPG storage and usage are also covered under the CAN/CSA-B149.2, *Propane Storage and Handling Code.*

7.8.2. LPG Laboratory Use

The *National Fire Code of Canada 2010 (including Quebec modifications)* and the *CAN/CSA-B149.2, Propane Storage and Handling Code* prohibit the use and storage of LPG cylinders within buildings. However, NFPA 58 allows certain amounts of LPG to be used depending on the building classification.

If a LPG is used for research purposes in University laboratories, the following rules shall apply:

- the cylinder must be “in use” (see section 7.6.4)
- the cylinder must be at least 20 feet away from cylinders containing oxidizing gases
- a leak test shall be performed every year and after replacing a cylinder and/or any modification of the installation
- a leak-detection system (e.g. detector) must be in place and tested annually or;
- the cylinder must be placed in a continuously mechanically ventilated gas cabinet

Any use or storage of LPG cylinders within laboratories must be assessed and approved by EHS.

7.8.3. LPG Storage Requirements

LPG cylinders not "in use" shall not be stored inside University buildings but in secured locations outside buildings according to the following recommendations:

- At least 5 ft. (1.5m) from any doorway or opening in a building frequented by the public where occupants have at least two means of egress
- At least 10 ft. (3m) from any doorway or opening in a building or sections of a building that only has one means of egress.
- At least 20 ft. (6.1m) from air intakes of air conditioning or ventilation systems.
- Cylinders shall not be stored on building roofs.

If empty cylinders that have been in LPG service are stored indoors, they shall be considered as full cylinders and must therefore be stored outside buildings.

7.9. Oxidizing Gases

Oxidizing gases are non-flammable but in the presence of an ignition source and fuel can support and vigorously accelerate combustion. Examples of oxidizing gases include:

- Oxygen
- Chlorine
- Fluorine
- Nitrous oxide

Do not use oil in any apparatus where oxygen will be used.

Cylinders that contain oxidizers whether full or empty must be stored away from fuel gas cylinders (e.g. propane, hydrogen, etc.) at a minimum of 20 feet. In the event they are stored together, they must be separated by a wall 5 feet high with a fire resistive barrier of at least 30 minutes. If the cylinders are stored indoors, the area must be fully sprinkle red.

7.10. Acetylene

Flashback arresters must be installed on the pressure regulators on both the acetylene cylinder and the oxygen cylinder with check valves for every 15 ft. of those used.

Acetylene is an extremely flammable gas. It is different from other flammable gases because it is also unstable. Under certain conditions, it can decompose explosively into its constituent elements, carbon and hydrogen. A flashback can occur if there is a flammable mixture of fuel gas and oxygen in the hoses when the torch is lit. If it is not stopped, the flame will ignite the mixture and will travel backwards from the torch, along the hoses, through the regulator and into the cylinder. A flashback can trigger decomposition of the acetylene in the fuel hose, in the regulator and in the cylinder itself.

8. Nanomaterials & Nanoparticles

Separate Nanomaterials Guidelines are available on-line from the EHS website.

Engineered nanoparticles are defined as materials purposefully produced with at least one dimension in the 1-100 nm range. Nanomaterials safety is in an area where there are a great many unknowns and little to no regulation. Hence, nanomaterials have to be handled in such a way that the known hazards are mitigated accordingly and unknown toxic effects are reduced by exposure protection means.

All users of nanomaterials must take the 'Safe Handling of Nanomaterials' training. This training is available upon request at ehs@concordia.ca. The nanomaterials safety program is led by the Chemical Safety Officer.

9. Biological Hazards

Separate Biosafety Manual, Procedures and Guidelines are available on-line from the EHS website. The *Laboratory Biosafety Standards and Guidelines* can be consulted on the Public Health Agency of Canada website.

Biohazardous materials are defined as material of biological origin that may be potentially harmful to humans, animals, plants, the economy or the environment. Biohazardous materials include (but are not limited to):

- Microorganisms such as viruses, fungi, parasites and bacteria;
- Biological toxins from microorganisms, plants and animals
- Human primary tissues, blood and body fluids;
- Materials that may contain the above-mentioned agents (e.g. cell cultures, specimens from humans and animals, environmental samples);
- Certain proteins, nucleic acids (siRNA, miRNA, DNA from pathogenic organisms, oncogenes);
- Genetically modified organisms (GMO) that may be hazardous to the environment if released.

All projects involving biological material must be registered with EHS to ensure that the work is compliant with internal policies and federal, provincial and municipal legislation. The biosafety program is under the responsibility of the Biosafety Officer (BSO) at the EHS Office.

10. Radiation Hazards

Separate Radiation Safety Manual, Procedures and Guidelines are available on-line from the EHS website.

Ionizing radiation emitted from radioisotopes and radiation-emitting devices is an essential tool in both the research and teaching activities of the University. Since ionizing radiation is hazardous, strict regulations have been developed in the form of federal legislation (Nuclear Safety and Control Act) and institutional policies to protect employees, students and the general public from unnecessary or potentially harmful levels of radiation exposure.

The radiation safety program is under the responsibility of the Radiation Safety Officer (RSO) at the EHS Office.

11. Magnetic Field Hazards

A separate Magnetic Field Safety Manual is available on-line from the EHS website.

Strong static and time-varying magnetic fields are generated by research and other equipment in various locations within University facilities (e.g. NMR, MRI, etc.). Although magnetic fields (both static and time-varying) and associated electromagnetic fields do not cause apparent long-term health effects, there are hazards, under some circumstances, which need to be recognized and controlled to avoid accidents or injury to equipment operators, researchers, support staff, students, visitors, and research subjects, as well as to the general public. The University is committed to complying with all federal and provincial guidance documents concerning the safe operation of equipment generating significant magnetic and electromagnetic fields as stated in VPS-54.

The magnetic field safety program is under the responsibility of the Radiation Safety Officer (RSO) at the EHS Office.

12. LASER Hazards

Separate LASER Safety Manual, Procedures and Guidelines are available from the EHS website. For additional information, you may also consult the webpage of the *Laser Institute of America; ANSI Z136 Standards*.

Concordia University's LASER safety policy (VPS-51) is based on the recommendations of ANSI Z136.1, any other pertinent standards, and in compliance with the Federal and Provincial regulations. The LASER safety program's primary objective is to ensure that no laser radiation in excess of the maximum permissible exposure (MPE) reaches the human eye or skin. This program is also intended to ensure adequate protection against laser- related non-beam hazards.

The LASER safety program covers all class 3B and class 4 lasers. **Every LASER installation of class 3B or 4 must have a LASER safety plan in place, and must be reviewed by the Laser Safety Officer.** The University's LASER Safety Program issues internal permits to University employees who are either the Principle Investigator or the person responsible of the location where the Class 3B or Class 4 lasers/laser systems are used or stored.

This program is under the responsibility of the LASER Safety Officer (LSO) at the EHS Office.

13. Hazardous Waste

13.1. Responsibilities

13.1.1. Faculty, staff, students, volunteers and visitors

To ensure compliance with regulations and guidelines, and for the safe handling and efficiency of operations, EHS has established standards applicable to the collection, labelling and packaging of hazardous waste by each waste generating department and laboratory.

Therefore, in addition to University individual's responsibilities mentioned VPS-40 and in Section 4.1 of this manual, anyone (faculty, staff, students, volunteers and visitors) generating hazardous waste as part

of any University Sanctioned Activities or overseeing spaces or working in areas (labs, studios or workshops) where hazardous waste are generated must:

- receive Hazardous Waste Disposal training, provided by or recognized by EHS;
- follow all relevant EHS waste disposal guidelines and procedures.

Furthermore, faculty, staff, students, volunteers and visitors **MUST NOT:**

- accept any chemical, hazardous substance or item containing hazardous substances as gifts or donations on behalf of the University without notifying EHS prior to the transfer. This is to ensure that no unanticipated future hazardous waste costs would result from such a transfer and for the safe transport by Distribution Services personnel;
- give or sell University property and equipment, including hazardous substances, to any person or organization outside the university except through the legally established procedures of the Purchasing Department or in the instance of hazardous materials, through EHS;
- dispose of any hazardous substance in regular garbage or down the drain.

13.1.2. Environmental Health & Safety (EHS)

Concerning hazardous waste management at the University, Environmental Health and Safety (EHS) must:

- ensure safe handling and transportation of hazardous waste within University premises;
- ensure proper storage of hazardous waste within secured locations having restricted access;
- enlist external resources to assist with the management, shipping, recycling or disposal of hazardous waste and ensure the proper legal certification and compliance of such external resources.

Under no circumstances will EHS personnel pick up chemical substances that do not follow the procedures and requirements listed in this section. Should the laboratory not be able to identify their waste, an analysis will be performed at the laboratory's expense.

13.2. Chemical Waste

Chemical waste is mainly generated as the chemical by-products of laboratory work as well as expired chemicals. This includes solids, liquids or gases containing or contaminated with any of the following:

- flammable and combustible solvents (e.g., acetone, alcohols, acetonitrile, oils)
- oxidizers (nitrates, perchlorates, permanganates, peroxydes)
- leachate toxic materials (e.g., heavy metals,)
- corrosives (e.g., hydrochloric acid, potassium hydroxide pellets)
- reactives such as oxidizers, cyanides, sulphides, explosives, unstable materials and water-reactive materials (e.g., sodium metal, benzoyl peroxide)
- toxic materials including mutagenic, carcinogenic, acute or chronic toxicity materials (e.g., chloroform, ethidium bromide)
- non-returnable gas cylinders

13.2.1. Containers for Chemical Waste

Collect substances by using the appropriately labeled University standard waste containers. The containers and labels are provided:

- by the Chemistry Central Store (SP-132.02, Loyola Campus) or
- by EHS (Loyola and SGW campuses) upon request (email hazardouswaste@concordia.ca).

Solvent glass bottles (4L) and other re-sealable chemical containers can be used for waste storage **only if**:

- they are in good conditions
- their labels have been obliterated
- the containers are clearly identified with a waste label.

Liquid chemical waste include mainly organic solvents, acid and base solutions, oils and aqueous solutions. The following plastic containers should be used for their disposal:

- 4 L narrow-mouth
- 10 L
- 20 L

Solid chemical waste includes powders, silica, sand, celite (or any other filtering media), contaminated paper, glassware, gloves or any other solid materials that have been contaminated with chemicals. The following plastic containers should be used for their disposal:

- 4 L wide-mouth
- 20 L white pail

If chemical waste is generated in large quantities that cannot be easily disposed of in our regular waste containers, special drums for bulk chemical waste are required.
Please contact EHS at hazardouswaste@concordia.ca to request a drum.

- **Size:** 210 L plastic or metal
- **Use:** liquids: oil, organic, corrosive, aqueous
  solids: non-corrosive chemicals and other contaminated materials

13.2.2. Expired Chemicals

Most chemicals have expiry dates. Expired chemicals in their original manufacturers' bottles are accepted for disposal as long as the bottle is in good condition and the label is legible. Empty chemical bottles with labels that are still legible can also be collected by EHS as chemical waste.

13.2.3. Empty Chemical Containers

Used 4L solvent bottles or containers which are empty can be disposed via regular garbage as long as they are properly cleaned. To properly clean a chemical bottle:

- Triple rinse the bottle (see Solvent Bottle Disposal Procedure)
- Remove original chemical labels and/or write "rinsed" on the label
- Remove the cap

Bottles and other glass containers which were used to contain or hold chemicals cannot be recycled through regular garbage.

13.2.4. Chemical Waste Pick-Up Procedure

Once you have hazardous chemical waste ready to be picked up, the following procedure must be followed:

1) Complete the Hazardous Waste Disposal Request Form by including the date, room number, phone extension and signature.
2) Include all the details about the hazardous waste (chemical name, quantity, container size). In the case of mixtures, please write down approximated percentage of each component.
3) Properly fill in the label on the waste container. Avoid using abbreviations.
4) For mixed waste, indicate approximate percentage of contents in order of highest to lowest concentration.
5) Send the duly completed form to the EHS office at hazardouswaste@concordia.ca.
6) Hazardous waste pickups are done on Tuesdays (LOY) and Thursdays (LOY+SGW) upon request.
7) Request for special hazardous waste pickups (emergency, bulk quantities, drums) must be sent directly to the EHS office by e-mail to hazardouswaste@concordia.ca

13.2.5. Guidelines

- All persons generating hazardous chemical waste must attend the Hazardous Waste Disposal training and follow the guidelines.
- Always allow 10-20% free space in liquid hazardous waste containers to allow for solvent expansion. Overfilled and/or leaking containers cannot be accepted for transport.
- Waste containers must be provided with a means of second containment in case of spill.
- Do not mix halogenated with non-halogenated organic waste. Organic solvents bulked together in the same waste container must be compatible.
- Segregate all waste according to compatibility following similar criteria as for chemical storage (see chart in chapter 7.4.2).
- All full containers should be placed in a designated waste area.
- Waste containers must not obstruct any exits.
- When accumulation exceeds the available storage limits within the laboratory area, arrange for the transfer of the waste by contacting EHS.

13.3. Biohazardous Waste

Biohazardous/biomedical waste refers to any material having the risk of carrying pathogens which can be potentially harmful. Biohazardous waste generated at the University includes:

- Human and animal blood and blood products.
- Cultures and stocks of etiologic agents and associated biological.
- Laboratory waste that has come in contact with a biological material: this includes but is not limited to culture dishes, blood specimen tubes, devices used to transfer, inoculate and mix cultures, and other materials which have come in contact with biological material (including disposable personal protective equipment and clothing).
- Sharps that have been in contact with biological materials.
- Animal waste, animal carcasses and body parts.

13.3.1. Containers for Biohazardous Waste

Any solid biohazardous waste material should be placed in an appropriate container or bag which bears the biohazard symbol. The biohazard waste containers can be obtained either:

- from the Chemistry Central Store (SP-132.02, Loyola Campus) or
- from EHS upon request (Loyola and SGW Campuses).

The following containers should be used for their disposal:

For non-anatomical waste:	**For anatomical waste:**	**For sharps:**
Grey bin with yellow bag inside  Gloves, plastic pipettes, blood products, other biological fluids	20 L red pail  carcasses, unfixed animal tissues, any items soiled with animal tissues	4 L yellow container  Syringes, needles, scalpels, Pasteur pipettes, slides

Animal carcasses must be placed in bags that are then stored in the designated biohazard freezer. All the data concerning this waste should also be recorded at the same time in the logbook located near

13.3.2. Decontamination Prior to Disposal

i. Autoclaves

- Autoclaves are ideal for decontaminating biohazardous waste prior to disposal with other refuse.
- Follow the manufacturer's procedures before autoclaving any biohazardous waste.
- Once autoclaved, material such as culture dishes can be disposed of with the regular garbage. However, the autoclave bag and its content must be placed inside a regular black tied-up garbage bag.
- **Never put an autoclaved bag or its content directly in the regular garbage.**

ii. Chemical Decontamination

- Cell culture waste can be destroyed by mixing with 1/10 vol. of bleach and letting it sit in a capped container for 24-48 hours at room temperature. The waste may then be dumped down the sink in a chemical hood with fresh tap water running for a few minutes after dumping the bleached waste.
- Chemical disinfectants are used for the decontamination of surfaces and equipment that cannot be autoclaved, such as specimen containers, spill clean-up material and certain glassware. The choice of disinfectant will depend upon the resistance of the microorganisms, convenience, stability, compatibility with the materials, and the health hazards.
- For general decontamination guidelines, please refer to the Biosafety Program webpage.

13.3.3. Biohazardous Waste Pickup Procedure

Once you have biohazardous waste ready to be picked up, the following procedure must be followed:

1) Make sure to properly close all waste containers to avoid contamination outside the working area once the containers are picked up.
2) Clearly identify any containers that contain anatomical waste.
3) Send the information for pickup by e-mail to hazardouswaste@concordia.ca.
4) Biohazardous waste pickups are generally done 24-48h after reception of request.

13.3.4. Guidelines

- Do not overfill biohazard waste containers.
- Do not try to compact waste with your hands or feet.
- If required, research laboratories can use other types of biohazard waste containers at their own expense provided that they are designed for the disposal of such waste. These containers will also be picked up during regular pickup rounds.

13.4. Radioactive Waste

Radioactive waste is defined as any waste containing radioactive material. The radioactive waste management at the University is under the strict control of the Radiation Safety Officer (RSO). Radioactive waste generated at the University is composed of sealed and unsealed radioactive sources, such as:

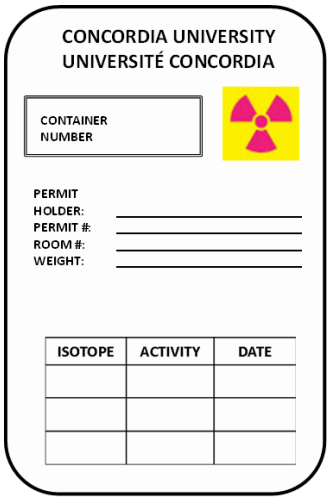
- Aqueous radioactive solutions
- Liquid scintillation counting fluid in vials
- Solid materials contaminated with radioactive material

13.4.1. Categories / Disposal

It is up to the RSO to establish a system of radioactive waste collection in all designated radioisotope laboratories. Only solid waste may be transported for disposal.

- Liquid (except scintillation vials) waste must be solidified (absorbed/adsorbed) before disposal
- Waste containers must bear the radioactive waste disposal tag:

Fig 13.4.1-1: radioactive waste disposal tag



Dry waste and scintillation vials
20 L pail lined with a clear polyethylene bag
Any other radioactive liquids

The radioactive waste containers and waste tags are available from the RSO.

13.4.2. Radioactive Waste Pickup Procedure

Once you have radioactive waste ready to be picked up, the following procedure must be followed:

1) A properly completed radioactive waste disposal tag must be completed and attached to each container of radioactive waste to be collected.
2) Each container is to be marked with a unique identification number, the name of the responsible person and the date.
3) A Radioactive Waste Disposal Form must be filled out.
4) A copy of the form must be provided to the RSO (the original must be retained for the logbook).
5) Contact the RSO to schedule a waste pickup.
6) All radioactive waste is either decayed or removed by a licensed carrier.

For more details, refer to the Radiation Safety Program webpage.

13.4.3. General Guidelines

- Radioactive waste must never be placed in non-radioactive waste containers.
- All waste containers are to be kept closed and shielded at all times.
- All radioactive waste is collected by EHS only.
- Only one type of radioisotope per waste container.

13.5. Sharps

A sharp is any item having corners, edges, or projections capable of cutting or piercing the skin. The following items (whether contaminated with hazardous waste or not) are considered sharps and must be disposed in puncture-proof containers and managed as sharps waste:

- Needles and syringes
- Scalpel and razor blades
- Glass such as Pasteur pipettes
- Any other items that are capable of puncturing

Broken glassware is not considered a sharp unless it is contaminated with hazardous waste.

13.5.1. Categories / Disposals

i. Sharps:

- Sharps that have been in contact only with chemicals should be disposed of in 4L or 20L containers for solid waste (refer to section 13.2, Chemical Waste)

Only sharps that have been in contact with any form of biological material (blood, serum or other body fluids, cultures, vaccines, organs, etc.) should be disposed of in biohazard containers.

ii. Broken Glass:

- In order to protect the laboratory and cleaning staff, all broken glass free of any contamination should be disposed of in dedicated broken glass boxes labelled “BROKEN GLASS”.
- No broken glass (contaminated or not) should be disposed of in regular garbage.
- These containers are picked up by the cleaning staff and are not to be re-used or recycled.
- Broken glass containers can be obtained from EHS.

For more details, please refer to the Broken Glass Waste Disposal Procedure

13.5.2. Guidelines

- Sharps should never be thrown away in regular garbage bins.
- Needles should not be bent, sheared, recapped or removed from the syringe.

13.6. Mixed Waste

Mixed hazardous waste is composed of materials that have been in contact with various sources of contaminations (chemical, biological or radioactive).

13.6.1. Disposal

The following order of priority should be used for disposal of mixed waste containing different types of hazards:

Radioactive > Biological > Chemical

For example: if sharps are contaminated with a mixture of hazardous components, treat them as follows:

- Biological and hazardous chemicals: do not autoclave and treat it as a biohazardous contaminated sharp
- Biological and radioactive: to be disposed as radioactive waste
- Biological, radioactive and hazardous chemicals: to be disposed as radioactive waste

13.7. Other Types of Hazardous Waste

They consist of any other types of waste materials considered to be dangerous for human health or the environment and cannot be thrown in regular garbage. At the University, such waste includes:

- full and/or empty paint containers
- lead/acid or lithium batteries
- toner cartridges
- fluorescent tubes or bulbs
- computers, printers and other electronic equipment (e-waste)

Information about other hazardous waste handling at Concordia can be found on the EHS Hazardous Waste webpage.

13.7.1. Disposal

For any other types of hazardous materials which may be recycled or require special care, including heavy items, please contact Facilities Management at x2400 to schedule pickups. Do not leave such waste in front of the different waste rooms as they can create tripping or spill hazards.

13.7.2. Concordia Recycling Depot Locations

Special recycling depots are available throughout both campuses. You can bring any old alkaline batteries, cellular phones, ink cartridges and other e-waste for recycling.

More details about recycling can be obtained at Sustainability-Zero Waste.

13.8. Non-Compliance

Disposal of hazardous waste is free of charge, provided proper waste disposal guidelines are followed. In the event that hazardous waste procedures are not respected, EHS will take the following actions:

1) First Infraction: A Non-Compliance Notice indicating the nature of the problem(s) encountered during the hazardous waste pickup.
2) Second Infraction: A Non-Compliance Notice indicating that the requester will be required to attend Hazardous Waste Management Training.
3) Third Infraction: A Non-Compliance Notice indicating all hazardous waste collection for the area is suspended and a meeting request with the individual responsible for the area (PI/Researcher/Supervisor) in order to determine the corrective actions necessary to resolve.

14. Physical Hazards

14.1. Electrical Safety

14.1.1. General Electrical Safety

Living organisms are electrical conductors and electrification occurs when there is a potential difference between two points in the organism. The danger of electrical accidents occurs not only from contact with a live conductor, but from a simultaneous contact with a live conductor and another body at a different potential. Electricity can be fatal even at low voltages and current. The risk and severity for injury will depend on the duration of the contact and the voltage involved. In addition, electricity is a potential ignition source which could lead to fire.

Below are electrical safety precautions applicable in a laboratory environment:

- Use only approved certified electrical equipment (CSA or ULC certified equipment).
- All electrical equipment must have grounded three-prong plugs. Never remove the ground pin of a three-pronged plug.
- Electrical outlets must not be overloaded (multi-outlet adapters should not be used; power bars must not be chained).
- Regularly inspect electrical cords and equipment. Tag and remove from service any defective equipment until repairs are completed.
- Damaged equipment must be reported to the Supervisor or responsible person.
- Electrical cords must be in good condition: frayed or defective cords must be repaired or replaced and reported to the Laboratory Supervisor or responsible person.
- When extension cords are used, the wire gauge shall be equal to or larger than the size of the cord being supplied by them.
- When removing electrical cords from outlets grasp and pull from the plug not by the cord.
- All power tools and appliances must be free of cracks, fraying, heat and insulation damage.
- Position electrical equipment so as to minimize the possibility of contact with water or chemicals. Be aware that condensation could enter the motor or controls.
- Issues involving the building electricity must be reported to the Service Centre at x2400.
- Access to electrical control panels, disconnect switches, and transformers must be kept clear of obstructions. By code, electrical control panels must have a 1m clearance.
- Electrical modifications and repairs must be made by electricians from Facilities Operations or authorized departmental technicians.

14.1.2. Static Electricity

The build-up or generation of static electricity within certain metallic pieces of equipment can create sparks which cause a significant fire hazard when flammable substances are being stored or used within their vicinity (e.g. solvent cabinets, drums, etc.). Therefore, static electricity must be dissipated through grounding set-ups before the handling or transfer of any flammable substances. Grounding must be applied to any metal piping or pump used during flammable solvent transfer operations.

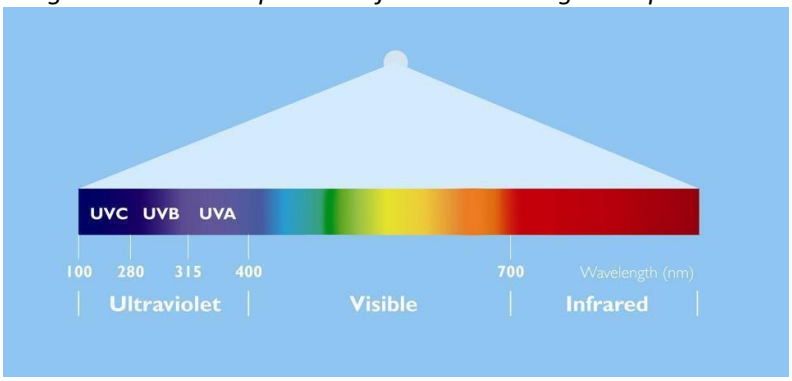
EHS recommends having the following items grounded, even in the absence of dispensing:

- Flammable solvent storage cabinets
- Metal drums or cans containing flammable solvents

14.2. UV Radiation

UV radiation is a non-ionizing form of radiation and invisible to the eye. UV radiation is found in the 100 nm to 400 nm wavelength region of the electromagnetic spectrum. Everyday exposure to ultraviolet radiation is typically in the UVA region resulting from exposure to direct sunlight. The Earth's atmosphere shields us from the more harmful UVC and greater than 99% of UVB radiation. However, some common laboratory equipment such as germicidal lamps in biological safety cabinets, UV curing lamps, black lights, trans illumination boxes and nucleic acid cross linkers can generate concentrated UV radiation in all the spectral regions. For example:

Fig. 14.2-1: UV components of the electromagnetic spectrum.



The use of equipment without the appropriate shielding and personal protective equipment can cause injury to skin and/or eyes within seconds of exposure. The severity of the effect will depend on the wavelength, intensity, and duration of exposure. The eyes are most sensitive to UV radiation and an exposure of a few seconds can result in photokeratitis and conjunctivitis. Photokeratitis is a condition caused by the inflammation of the cornea of the eye. Conjunctivitis is the inflammation of the conjunctiva causing discomfort and a watery discharge. Chronic skin exposure to UV radiation has been linked to premature skin aging and skin cancers. Chronic exposures to the eye can lead to the formation of cataracts.

The following safety measures should be implemented to limit UV exposure:

- Never allow the skin or eyes to be exposed to a UV radiation source
- UV enclosures and interlocks supplied by the manufacturer must be used at all times. Refer to the manufacturer's safety precautions and user manuals.

- Never work in a biological safety cabinet while the germicidal lamp is on.
- UV exposure may be minimized by limiting exposure time and increasing the distance to the UV source.
- Use appropriate PPE such as safety goggles with UV protection, UV face shields, long sleeves and tightly-woven clothing that cover much of the body, and appropriate gloves. Application of sunscreen with high sun protection factor against UVA and UVB can provide limited protection but should not be used as the only means of protection.
- Equipment that emits UV radiation shall have a proper caution label. The label should state an appropriate warning such as: CAUTION UV RADIATION HAZARD USE ONLY WITH SHIELDING IN PLACE PROTECT EYES AND SKIN FROM EXPOSURE TO UV LIGHT

14.3. Glassware

Glassware is used, cleaned and stored in all laboratories. These are generally used for laboratory experiments and include items such as pipettes, burettes, graduated cylinders, volumetric flasks, beakers, flasks, test tubes, etc. Glassware can be mishandled and broken causing a workplace injury. Glassware should be substituted with non-glass laboratory products whenever possible. Alternatives can include products made from polymethylpentene (PMP), high-density polyethylene (HDPE), low-density polyethylene (LDPE), polycarbonate (PC) and Teflon (TFE). The following precautions should be implemented when using glassware:

- Ensure that the glassware is designed for its intended use; borosilicate glassware is recommended for most laboratory applications. Certain applications may require the use of Pyrex™ shatterproof glassware.
- Use appropriate PPE such as insulated gloves or tools such as tongs when handling heated glassware. Extreme caution should be used when working with glassware at very high or low temperatures.
- Glassware should be cleaned as soon as possible.
- Glassware should be rinsed thoroughly to prevent contamination. Do not towel dry glassware but allow to air dry.

Glassware should be inspected before use to ensure it is free from any defects or particulate matter. Any glassware with chips, cracks or scratches should be removed from service, repaired or disposed of properly (refer to the waste procedures in Chapter 13, Hazardous Waste.

14.4. Ergonomics

Ergonomics is the study of the way in which people work and interact with the characteristics of their work environment. It includes finding ways to be more efficient, as well as ways to protect people from sustaining injuries from repetitive tasks. The goal is to design the job to fit the worker rather than physically forcing the worker's body to fit the job. This can be achieved by creating a comfortable environment with the application of ergonomic principles, such as:

- Avoiding overreaching, repetition, awkward posture, direct pressure to muscles, fatigue and force.
- Understanding how to adjust our work environment to accommodate our individual needs.
- Applying principles of good posture and habits.

The height of work surfaces and laboratory benches is often difficult to adjust. However, chairs and laboratory stools should be adjustable in height and foot stools can be used to accommodate for a person's height. Repetitive movements and tasks should be identified and adjustments made for activities that enable changes in posture and motions. For example: a repetitive task could be rotated between employees.

Proper lighting is also an important ergonomic factor and task lighting can be used to supplement the general laboratory lighting.

Laboratory ergonomic tips:

- Adjust the microscope workstation to support a good work posture; avoid leaning forward by adjusting the eyepieces, tube length and angle; adjust the chair and work surface to provide good back and foot support.
- Adjust the armrests so that fingers are positioned to reach the height of the microscope dials to avoid elevating the arms and hands without proper support.
- Use shorter pipettes in order to decrease hand elevation and consequent awkward postures; position the tips and discard containers to avoid rotating the wrist when picking up or ejecting tips.
- Use electronic pipettes for highly repetitive tasks that require prolonged pipetting.
- When working in a biosafety cabinet or on the laboratory bench, position materials as close as possible to avoid extended reach.
- Microtome & cryostat work: lower the workstation to keep arms closer to the body; apply padding to the front edge of work surfaces to eliminate sharp edges that may prevent adequate blood flow to the hands.
- Use anti-fatigue mats for any work that requires standing for extended periods of time.
- Take frequent mini-breaks; these breaks should be used to change position and perform stretching exercises

For an office environment or working with computers, refer to the EHS Ergonomic Program to set up your office or computer work station. Laboratory users should also consult the Laboratory Ergonomics poster.

14.5. Noise

In a work environment, prolonged or repeated exposure to different noise levels can affect the efficiency with which a task is performed and lead to short and long-term hearing loss. Noise can often interfere with verbal communications between people and can be distracting to tasks that need a certain level of analytical concentration.

How we perceive sound depends on the frequency or pitch of the sound. We hear certain frequencies better than others. If we hear two sounds of the same sound pressure but of different frequencies, one sound may appear louder than the other. This is because we hear high frequency noise much better than low frequency noise.

Therefore, noise measurement readings are adjusted to correspond to this peculiarity of human hearing. Measurements are taken using an A-weighting filter which is built into the instrument that de-emphasizes low frequencies or pitches. Decibels measured in this manner are A-weighted and are called dB(A). Examples of workplace noise levels are given in the table 14.5-1.

Table 14.5-1: CSA Guidelines (Z412, 2011)

dBA	Location
90	Industrial setting, Quebec regulation
60	Industrial customer service area
55	Circulation area
50	Call centre
45-48	Open area cubicle
45	Closed office
30 +	Videoconference room
35	Conference room
35	Executive office

Most laboratory environments do not produce noise levels that require the use of hearing protection. Noise level in laboratories generally does not exceed 60 dBA. However, certain equipment and operations may exceed the recommended provincial limit of 90 decibels (dBA). Concordia University has even lowered its exposure limit to a value of **85 dBA for a typical 40h work week**. The most common noisy equipment are sonicators and wind tunnels. Laboratories using these types of equipment and operations should have proper hearing protection available to all users.

15. Equipment Safety

Equipment must be maintained properly in accordance with the manufacturers' instructions. The safe use of laboratory equipment must be ensured by the PI or Laboratory Supervisor. The following precautions should be observed:

- Read the manufacturer's instructions and keep available in an accessible location for future reference.
- Use and service equipment according to the manufacturer's instructions.

- Staff and students must be properly trained in the setup, use and cleaning of the equipment. The EHS orientation checklist can be used to record that proper training was given.
- Decontaminate equipment before maintenance is performed or sent out for repair.

15.1. Refrigerators and Freezers

Only refrigerators and freezers designed for laboratory use should be used for the storage of chemicals. Due to the potential hazards involving vapours and possible spillage, laboratory refrigerators/freezers are constructed with special design factors. Heavy-duty cords and corrosion resistant interiors reduce the risk of fire or explosions in a lab. In contrast, standard domestic refrigerators have electrical fans and motors that make them potential ignition sources for flammable vapours.

- Do not store flammable liquids in a refrigerator unless it is approved for such storage.
- Only chemicals are to be stored in chemical storage refrigerators.
- Laboratory refrigerators must not be used for food and beverage storage.
- Laboratory refrigerators must be labelled for their intended purpose such as: “No Food or Drink” or “chemicals / laboratory use only”. Each department has a lounge / kitchen area with a refrigerator for staff use.
- All materials in refrigerators or freezers must be labelled according to WHMIS regulations.
- All containers must be sealed, preferably with a cap. Containers should be placed in secondary containers, or spill proof pans/trays.

15.2. Centrifuges

Please refer to the document Safe Use of Centrifuges posted on the Biosafety webpage.

Spills, leaks, tube breakage or improper use of safety cups/rotors can result in generation of biohazardous aerosols during centrifugation. Recommendations for safe centrifugation of biohazardous material include:

- Use the centrifuge according to the manufacturer’s instructions and laboratory SOP:
    - Ensure that the centrifuge is properly balanced;
    - Use tubes intended for centrifugation, e.g. plastic thick-walled tubes with exterior thread screw caps;
        - Check tubes for stress lines, hairline cracks and chipped rims before use;
        - Never fill tubes to the rim;

- Use sealed centrifuge cups/rotors:
    - Inspect cup/rotor seal integrity regularly and replace if cracked or dry;
    - Load and unload infectious materials or toxins inside a BSC;
    - Allow time for aerosols to settle before opening cups/rotors;
    - Decontaminate the outside of the cups/rotors before and after centrifugation;

- Do not open the centrifuge lid during or immediately after operation, attempt to stop a spinning rotor by hand or with an object, or interfere with the interlock safety device;
- Clean spills promptly;
- Prohibit the use of centrifuges in a BSC.

15.3. Autoclaves

Autoclaves are used to effectively decontaminate biological waste by killing pathogens by means of superheated steam. First-time users must receive hands-on training prior to using an autoclave; a list of the individual(s) responsible for this training is posted near each autoclave. This training must be documented by completing and forwarding the *Training Attendance/Compliance Record* form to EHS.

Autoclaves must be loaded so that steam is able to penetrate into the innermost areas of autoclave bags, containers or equipment. Longer processing times are required for larger loads, larger volumes of liquids and denser materials. Effective operating parameters must be established whenever autoclaves are used to decontaminate biological waste. The autoclave efficacy monitory program is overseen by EHS: please contact the BSO.

Please refer to the document Safe Use of Autoclaves posted on the Biosafety webpage.

15.3.1. General Guidelines

- Only trained personnel are authorized to operate the autoclaves. The training is usually provided by designated departmental staff and must be recorded (EHS FORM 032 may be used to record the training).
- Autoclave sterility testing should be conducted on a regular basis to monitor efficacy. Contact EHS for more information.
- Do not put sharp or pointy objects into an autoclave bag. Place them in an appropriate rigid sharps disposal container.
- Laboratory waste and lab ware to be sterilized should not be mixed together during an autoclave cycle. They require different decontamination times.
- Proper personal protective equipment such as heat-resistant gloves, safety glasses and a lab coat must be worn when operating an autoclave.
- Autoclaves should be placed under preventive maintenance contracts to ensure they are operating properly.
- Thermometers cannot be autoclaved

15.3.2. Autoclave Loading

- Do not overload the autoclave since the steam will not be efficiently distributed. Longer sterilization times will be required.
- Use caution when handling a waste bag.
- When autoclaving bags: lift bags from the bottom to load them into the chamber. Use a secondary container tray to catch any potential leakage.
- Do not overfill an autoclave bag. The steam and heat will not go through a densely packed bag, therefore only the outer contents of the bag will be treated.
- Inspect glassware for cracks, failures etc. **before** putting them in the autoclave. Shield or wrap open glassware.
- Do not seal the bag tightly before autoclaving: the steam needs to enter into the bag and be in contact with the waste for proper decontamination.
- Seals on containers of liquids should be loose to allow for vapour expansion during heating preventing an explosion. Never autoclave any flammable or volatile liquids because they could explode.

15.3.3. Autoclave Unloading

- Use caution when opening the autoclave door. Allow for the superheated steam to cool and pressure to return to normal level before attempting to open the autoclave door.
- Handle pressurized containers carefully. The superheated liquids boil over from closed containers.
- Broken glass in the autoclave must be cleaned up using tongs, forceps or other instruments to recover broken pieces. Do not use bare or gloved hands to pick up broken glassware.
- Allow the autoclave to cool before cleaning.
- Autoclaved waste shall be placed in a regular black garbage bag and sealed prior to collection by Custodial Services.
- Any item bearing a biohazard symbol (such as red/orange/yellow biohazardous waste bags) will not be picked up.

15.4. Sonicators, Mixers and Grinders

Mixing equipment can pose a number of hazards such as dispersing chemicals, generating hazardous aerosols and creating physical hazards such as moving parts and noise. The following precautions should be considered when using mixing equipment:

- Equipment that may generate CL2 biohazardous aerosols must be used and opened in the biosafety cabinet.
- Wait 2-5 minutes after operating to ensure that aerosols have settled before opening containers.
- Wear appropriate PPE such as: lab coat, safety glasses/goggles, respiratory and hearing protection.

15.5. Bunsen Burners

Bunsen burners produce a single open flame by burning a continuous stream of flammable gas used for heating, sterilization, and combustion. As a result, they present a fire hazard and a potential for an accident to occur. If possible, Bunsen burners should be replaced with safer alternatives such as:

- Electrical incinerators
- Touch-plate microburners
- Pre-sterilized inoculating loops, spreaders, and needles
- Bead Sterilizers

Furthermore, biological safety cabinets (BSCs) and disposable sterile items obviate the need for open flames when aseptic conditions are needed. If a Bunsen burner cannot be replaced, it is important that the following guidelines be observed:

- Place the Bunsen burner away from any overhead shelving, equipment, or light fixtures.
- Remove all papers, notebooks, combustible materials and excess chemicals from the area.
- Tie-back any long hair, dangling jewelry, or loose clothing.
- Wear appropriate PPE; flexible gloves (e.g. latex or nitrile) should be removed when lighting up or working in close proximity to a working Bunsen burner.
- Avoid wearing synthetic clothing (e.g. polyester).
- Inspect hose for cracks, holes, pinched points, or any other defect and ensure that the hose fits securely on the gas valve and the Bunsen burner.

- Replace all hoses found to have a defect before using. Rubber tubing of 3/8" diameter is usually recommended.
- Notify others in the laboratory that burner will be in use.
- Utilize a sparker/lighter with extended nozzle to ignite the Bunsen burner. Never use a match or pocket-size lighter to ignite burner.
- Adjust the flame by turning the collar to regulate air flow and produce an appropriate flame for the experiment (typically a medium blue flame).
- Do not leave open flames unattended and never leave laboratory while burner is on.
- Shut-off gas when its use is complete.
- Allow the burner to cool before handling.

The use of Bunsen burners inside of a biological safety cabinet (BSC) is prohibited because it:

- Disrupts airflow, compromising the protection of the worker and the product;
- Causes excessive heat build-up within the cabinet;
- May damage the HEPA filter or melt the adhesive holding the filter together, compromising the cabinet's integrity;
- Presents a potential fire or explosion hazard within the cabinet;
- Inactivates manufacturer's warranties or any other certification on the cabinet.

In the event of fire, attempts to extinguish fire should only be done by people trained in fire extinguisher use. In all cases, people must activate the nearest fire alarm pull station, alert Security (x3717) and evacuate the laboratory.

15.6. Hot Plates, Ovens and Microwaves

All heating equipment must be in good working order before use. Exercise caution when heating liquids as superheating can cause injury. The following precautions should be considered when using these types of equipment:

- Avoid contact between flammable vapours and heating elements or spark-producing components of equipment.
- Avoid heating toxic materials in an oven unless it is properly vented through engineering controls to the outdoors.
- Do not use laboratory equipment for the preparation of food.
- Do not place closed or sealed containers inside microwave ovens: heating up materials in sealed containers can lead to a potential explosion and damage to the microwave oven, resulting in potential injuries to laboratory users. It is therefore important to always assure that vials heated inside of them have a way to vent any excess pressure generated.
- Most microwave ovens used within research laboratories are typically the ones designed for home use, which do not have pressure and/or temperature controls and therefore cannot prevent explosions from happening.

15.7. Water Baths

A water bath is a device that maintains water at a constant temperature. It is used in the laboratory for incubations. Water baths can become contaminated and pose aerosol hazards. To prevent contamination the water bath should be cleaned and disinfected regularly. The following precautions should be taken into consideration when using a water bath:

- When operating, keep minimum water level according to the manufacturer's recommendation. Never operate an empty water bath.
- The water bath should be disconnected before filling or emptying.
- Keep away from flammable and combustible materials.
- Use a non-mercury thermometer for visual monitoring of the bath temperature.

16. Personal Protective Equipment (PPE)

Personal protective equipment (PPE) is necessary to work with most hazardous materials and/or to perform certain experiments. It may also be necessary to supplement the safety equipment in laboratories such as the fume hoods. Proper PPE selection is essential for adequate protection from the hazards. PPE must be available and supplied to all staff by the laboratory PI or Supervisor. The SOP must specify the necessary PPE; signage may be posted in the laboratory to indicate mandatory PPE. For more details concerning Concordia University policy on personal protective equipment, please refer to Concordia University VPS-41.

16.1. Laboratory Clothing

Lab coats are required in all laboratories. These are available in various designs and materials and the choice should depend on the type of work being done and the hazards involved. Table 16.1-1 summarizes the pros and cons of the different fabrics used in lab coats confection.

The following recommendations shall be respected:

- Lab coats shall be worn and closed at all times in the laboratory areas.
- Lab coats must not be worn in the lunchroom, cafeteria, public areas or anywhere other than in the laboratory to prevent contamination of non-laboratory areas (caused by possible absorption and accumulation of chemicals in the material).
- Long-sleeved and long-legged clothing should be worn beneath the lab coat to protect the skin in case of a spill. Shorts, Capri pants and skirts should not be worn in a laboratory.
- For best protection a lab coat should be knee length and have long sleeves to the wrist.
- Lab coats with knit cuffs offer a better protection than those with open sleeve ends.
- Lab coats with snap front buttons can be removed easier and faster than lab coats with traditional buttons.
- Contaminated lab coats should not be washed at home with other laundry. A cleaning service is provided by certain departments.
- Lab coats should be provided and worn by all visitors entering a laboratory.

Table 16.1-1: Lab coat Fabrics Features

Material/Source	Features	Pros	Cons
Polyester/Cotton Blend 80% Polyester / 20% Cotton, 65/35, and 40/60 are common blends. • **Lab Supply Companies** • **Chemistry Stockroom** • **Biology Stockroom**	**Liquid Resistance** Splash resistant. No specific chemical resistance. Anecdotal evidence suggests polyester blends provide better protection against corrosive material than does cotton. **Flame Resistance** No Polyester blends burn more readily than 100% cotton or flame-resistant materials. **Comfort** Lightweight and breathable. More cotton in the blend results in better breathability.	Appropriate for use in clinical settings and research laboratories where biological material is manipulated.	Polyester blends burn readily when ignited, and are not appropriate for use with flammable liquids, pyrophoric materials, or near open flame.
100% Cotton • **Lab Supply Companies** • **Chemistry Stockroom** • **Biology Stockroom**	**Liquid Resistance** Not splash resistant. No specific chemical resistance. Anecdotal evidence suggests cotton lab coats provide better protection from solvent contamination than corrosive contamination. **Flame Resistance** No Burns less readily than polyester blends. **Comfort** Lightweight and breathable.	Appropriate for use in clinical settings and research laboratories where there is light flammable liquid or open flame use.	Cotton lab coats should be supplemented with a chemical splash apron when corrosive material is handled.
100% Cotton treated with flame retardant. • **Lab Supply Companies** • **Manufacturers of flame-resistant garments.**	**Liquid Resistance** Not splash resistant. No specific chemical resistance. Anecdotal evidence suggests cotton lab coats provide better protection from solvent contamination than corrosive contamination. **Flame Resistance** Yes Flame-resistant (FR) fabrics and garments are intended to resist ignition, prevent the spread of flames away from the immediate	Appropriate for use in research laboratories where substantial fire risk exists from flammable material handling or open flame use. Laundering will not damage the flame resistant coating.	More costly than a traditional 100% cotton lab coat.

	area of high heat impingement, and to self-extinguish almost immediately upon removal of the ignition source. **Comfort** Lightweight and breathable.		
Nomex IIIA • **Lab Supply Companies** • **Manufacturers of flame-resistant garments.**	**Liquid Resistance** Some chemical resistance **Flame Resistance** Yes When in contact with direct flame or extreme heat, fibers in the protective clothing enlarge, enabling greater distance between the user's skin and heat source. **Comfort** Breathable, but slightly bulkier than polyester blend or 100% cotton materials.	Appropriate for use in research laboratories where there is extreme fire danger from open flame, electrical arc flash, and pyrophoric material.	Expensive.
Polypropylene • **Lab Supply Companies**	**Liquid Resistance** Not splash resistant. **Flame Resistance** Not flame-resistant. **Comfort** Very lightweight and breathable.	Appropriate for use when protection from dirt and grime in nonhazardous environments is desired. Disposable. Low cost.	Offers no protection from hazardous materials.
Microbreathe • **Lab Supply Companies** • **Clean Room Supply Companies**	**Liquid Resistance** Barrier to particles, biological fluids, and chemicals. **Flame Resistance** Not flame-resistant. **Comfort** Lightweight, breathable, and stretches to allow ease of movement.	Appropriate for use in clinical settings and research laboratories where biological material and chemicals are handled. Low particle count fabric is ideal for clean room activities. Disposable.	Inappropriate for use in environments with a significant fire danger.

Shoes must be worn at all times: sandals, high heel shoes, flip flops, canvas toed shoes, crocs as well as open-toed and open-backed shoes should be avoided due to the danger of spillage of corrosive or irritating chemicals and broken glass.

16.2. Gloves

Protective gloves should be worn to prevent potential exposure to chemicals or biological material. The proper type of glove will depend on the materials being used. Different glove types have different

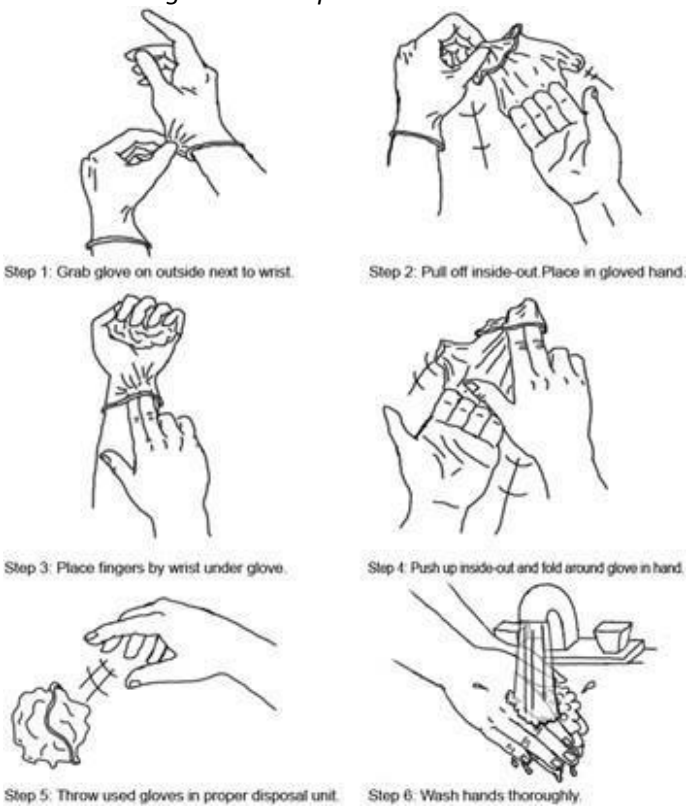
chemical permeability. Always consult the manufacturer's compatibility chart for proper glove selection. MSDS are also an important source of information.

16.2.1. General Guidelines

The following recommendations are important to consider:

- Always inspect your gloves for discoloration, punctures, and tears. If unsure as to whether the glove was compromised it should be replaced immediately.
- Do not reuse disposable gloves.
- Disposable latex gloves are not recommended for use with chemicals.
- Rubber or plastic gloves should **never** be used to pick up hot objects: hot objects should be picked up with gloves made of heat-resistant materials.
- Very cold objects (such as liquid N_2 or CO_2) should only be handled when wearing insulated gloves.
- Gloves must be removed before leaving the laboratory to prevent contamination of doorknobs, telephones, light switches, computers, elevator panels, etc.
- Gloves should be removed before handling personal items (cellphones, laptops, etc.).
- Wash hands after removing gloves and before leaving the lab.

Fig 16.2-1: Proper Glove Removal



16.2.2. Glove Selection

All glove-making manufacturers offer glove compatibility or chemical resistance charts for their gloves. These charts can be used to ensure the gloves selected will provide adequate protection for the wearer when handling a given chemical. It is important to note that all chemicals will not be listed on these charts and that two similar gloves supplied by two separate manufacturers may not provide the same level of protection to a specific chemical. Therefore, it is necessary to consult the manufacturer's specific compatibility chart for the brand of gloves being used.

Understanding terms used in glove compatibility charts:

- Breakthrough time: time it takes for the chemical to travel through the glove material. This is only recorded at the detectable level on the inside surface of the glove.
- Permeation Rate: time it takes for the chemical to pass through the glove once breakthrough has occurred. This involves the absorption of the chemical into the glove material, migration of the chemical through the material, and then de-absorption once it is inside the glove.
- Degradation rating: this is the physical change that will happen to the glove material as it is affected by the chemical. This includes, but is not limited to, swelling, shrinking, hardening, cracking, etc. of the glove material.
- Compatibility charts rating systems will vary by the manufacturer's design of their chart. Many use a color code, where red = bad, yellow = not recommended, green = good, or some variation of this scheme. A letter code may be used, such as E + excellent, G = Good, P = poor, NR = Not Recommended. Any combination of these schemes may be used, so please understand the chart before making a decision on the glove to be used.

16.2.3. Allergies

As research facilities have increasingly moved away from latex exam gloves because of their sensitization potential, other types of skin irritation and allergy to non-latex gloves have also increased. Some people can potentially develop an allergic contact dermatitis with the use of nitrile gloves, mainly caused by chemical accelerators used in the production of nitrile and other latex-free gloves. While vinyl gloves may be an option in some circumstances, they lack the elastic quality of nitrile and latex gloves, and may not provide the same level of protection. Alternative glove options are available from different suppliers against nitrile and latex allergies such as:

- Accelerator-free nitrile gloves;
- Nitrile with aloe gloves, which are easier on the skin;
- Cotton liners (for sweaty hands too): they put a barrier between the glove and the skin and also absorb some of the moisture, which can also give a rash.
- Neo-Pro gloves (Neoprene chloroprene).

16.3. Eye and Face Protection

Wearing eye and face protection is necessary to protect against splashing chemicals, biological materials and flying particles. Eye protection in the form of glasses, goggles or face shields is available and the choice will depend on the risk involved with the experiment, the type and the amount of material being used. The experiment's SOP should specify the necessary eye and face protection.

The following provides general information and precautions:

- Safety glasses shall be worn at all times in the laboratory areas.
- Regular prescription glasses with side shields may not provide sufficient protection. Contact EHS for additional information or an evaluation.
- Safety glasses are used to protect against flying particles.
- Safety goggles fit tightly around the face and offer protection against chemical splashes and can better protect against dust and smaller particles.
- When working with chemical vapours that can irritate eyes, a non-vented goggle with no padding is recommended. Anti-fog coatings are available on most models.
- Specialized protective eyewear is also necessary for working with lasers.
- Consult the MSDS to choose the right type of protection in accordance with the CSA standard for Industrial Eye and Face Protectors CAN/CSA Z94.3.

16.3.1. Proper Fit

- Safety glasses should be individually assigned and fitted.
- Ensure safety glasses fit properly. Eye size, bridge size and temple length all vary.
- Wear safety glasses so that the temples fit comfortably over the ears. The frame should be as close to the face as possible and adequately supported by the bridge of the nose.

16.3.2. Care

- Clean safety glasses/goggles daily. Follow the manufacturer's instructions. Avoid rough handling that can scratch lenses.
- Replace scratched, pitted, broken, bent or ill-fitting glasses. Damaged glasses interfere with vision and do not provide proper protection.
- Store safety glasses in a clean, dry place where they cannot fall or be stepped on. Keep them in a case when they are not being worn.

16.3.3. Face Shields

- A face shield must be used in combination with and worn over safety glasses or prescription glasses. (According to CAN/CSA Z94.3, face shields are considered secondary protectors only and provide adequate eye protection only when worn with safety glasses or goggles.)
- Face shields must be worn in conditions such as laboratory operations using glassware that has a significant hazard of explosion or breakage.
- When conducting experiments that may splash, face shield shall be worn in combination with safety goggles.
- Face shield must be used when working with cryogenics and UV sources.

16.3.4. Contact Lenses in the Laboratory

Due to the ever-increasing use of contact lenses and the benefits they provide to their users, major safety associations such as the National Institute for Occupational Safety and Health, the American Chemical Society Committee on Chemical Safety and the American College of Occupational and Environmental Medicine have conducted several risk assessments and have approved wearing contact lenses in work environments using chemicals, **provided that adequate eye protection is worn**.

Contact lenses can be worn in work areas where chemicals are used once EHS has conducted an **eye injury hazard** evaluation of the area. This evaluation will take into consideration potential chemical exposure and appropriate eye and face protection required for the hazards present.

In all instances where contact lenses are worn, protective eyewear is mandatory for the identified hazards present in the workplace (in compliance with the CAN/CSA Z94.3-07 Eye and Face Protectors standard).

Anyone authorized to wear contact lens in the workplace should be aware of the following:

- Wearing contact lenses reduce the eye's ability to tear. Tears naturally remove irritants from the eye.
- Contact lenses are permeable to certain vapours and as a result, some chemicals may become trapped between the eye and the contact lens.
- Eye wash stations usually dislodge contact lenses from the user's eyes. Users must **ensure** contact lenses are **completely removed** during eye flushing for first aid treatment to be effective.
- Inserting or removing contact lenses is not permitted in the laboratory. This should be done in a clean environment.
- When no local exhaust system or other exposure control measures are in place, contact lenses are not to be worn when handling the following chemicals: acrylonitrile, methylene chloride (dichloromethane), 1,2-dibromo-3-chloropropane, ethylene oxide and methylene dianiline chemicals.
- A pair of prescription glasses must always be accessible in the event that contact lenses cannot be worn during a particular experiment or procedure.

Emergency Procedure

If chemical vapours permeate the contact lens and compromise the eyes, follow to the outline safety procedure:

- Immediately flush the eyes for **at least 15 to 30 minutes;**
- Ensure contact lenses are removed while flushing with the eyewash; if not, remove contact lenses with **clean** hands.
- Contact or get someone to contact Security at X3717 while rinsing and advise a Supervisor;
- Complete an Injury/Near-miss Report and submit to EHS.
- See medical attention as soon as possible for a diagnosis and follow-up.

16.4. Respiratory Protection

Respiratory hazards in a laboratory can consist of chemical vapours, gases and particulates such as dust, fumes and biological materials. Fume hoods and general laboratory ventilation are generally sufficient to protect workers. A risk evaluation or assessment can determine if the engineering safety equipment is sufficient or a respirator is required. The specific type of respirator information should be included in the laboratory SOP. Good practices dictate that an appropriate respirator should be available and used in an emergency situation such as a hazardous spill.

Anyone who has to use a respirator (full face or half-face) for their work must first be fit-tested annually by EHS. Fit-testing is the only way to ensure that full respiratory protection can be achieved. To get a fit-test appointment, please contact EHS at ehs@concordia.ca.

Replace your respirator when it is:

- Damaged
- Soiled
- Causing increased breathing resistance

16.5. Hearing Protection

Hearing protection should be worn if average noise levels are greater than University standards (85 dBA) over an 8-hour period. Short periods of time at noise levels greater than 85 dBA are permissible without hearing protection. A hazard evaluation to measure the sound level is required to determine if hearing protection is necessary. Ideally, reducing the noise at the source is favoured over hearing protection. Efforts should be made to include noise reduction measures in the purchase of noisy equipment. Furthermore, plug-type (disposable or reusable) or muff-type hearing protection can also be used.

17. Emergency Procedures

17.1. Injury and Incident Reporting

There are specific accident reporting procedures at the University, as required by the *Act Respecting Occupational Health and Safety* and the *Act Respecting Industrial Accidents and Occupational Diseases* and their regulations. Everyone working in the laboratory must be aware that accidents and incidents should immediately be reported to Security and to the Supervisor. An Injury/Near-Miss Report must be completed as soon as possible (no later than 24 hours) after an injury or incident. All incidents and accidents are investigated in order to implement the appropriate measures to prevent the incident from reoccurring.

First aid is available in the event of an accident or incident; a list of area first-aiders should be available in or near the first aid kit.

All workplace accidents requiring absence from work must be reported immediately to the Supervisor and Human Resources. Injured employees should go to a physician and take along a Temporary Work Assignment Form provided by the Supervisor or department head if time loss is anticipated. The physician will fill out these forms. All paperwork provided by the physician should be brought to Human Resources to file a CNESST claim, if necessary.

Complete and sign the "CNESST EMPLOYER NOTICE AND REIMBURSEMENT CLAIM" (Form 1940) and "CNESST WORKER'S CLAIM" (Form 1939) and bring the forms to Human Resources **no later than 24 hours after the injury**. If the employee is unable to do so, they may authorize their Union delegate to represent them. Failure to report work-related injuries/illnesses may result in the denial of benefits under worker's compensation.

For further information, consult the HR Department webpage.

17.2. Fire and Egress

17.2.1. Fire

If smoke and/or fire are detected, follow the instructions below.

Alert	Activate the nearest alarm-pull box, and call Security by dialling x3717. Give your name and report the exact location of the fire.
Confine	Close all doors in fire area to confine fire and smoke.
Evacuate	Evacuate the area immediately and meet with the security agents, do not hesitate to contact Security if fire is suspected.

Assist the fire response team and security agents as requested. Do not use the elevators to evacuate unless directed by the security agents or the Fire Department. Follow EXIT signs that identify the nearest route of egress and once outside move away from the building.

Always alert Security or assign someone to do so before dealing with a fire. Fire extinguishers are provided by the University in corridors, public areas, laboratories, and other locations as required by building and safety codes.

In the event of a fire, laboratory users are not expected to extinguish the fire themselves. Laboratory users who have been trained to use a fire extinguisher may attempt to extinguish the fire safely. To do so:

- Make sure a clear escape route is available before attempting to deal with the fire.
- If a laboratory user is trained to use a fire extinguisher and feels that the fire can be controlled, they may use the PASS method to extinguish the fire:
  - **P** – Pull and turn the locking pin to break the seal
  - **A** – Aim low by pointing the nozzle or hose at the base of the flames
  - **S** – Squeeze the handle to release the extinguishing agent
  - **S** – Sweep from side to side until the fire is out
- Extinguishers work for approximately 30 seconds: if the fire has not been extinguished in that time, leave the area immediately.
- When leaving, close the door and **do not lock it**.

If the fire cannot be controlled with the extinguisher follow evacuation procedures that have been established and practiced during fire drills.

For additional information refer to the University's Emergency Management webpage.

17.2.2. Egress

Make certain that all means of egress in the laboratory are unobstructed at all times. Become familiar with the area-specific fire plan. Identify escape routes from the work area.

17.3. Power Failure

In the event of a power failure, general ventilation may be compromised and laboratory equipment may not function, including **fume hoods, BSC**, etc. Therefore, all experiments must be either paused or halted and fume hoods and BSC sashes must be lowered. No further laboratory activity should be conducted until power is restored

17.4. Spills

Because hazardous materials are used in laboratories, studios, workshops, and service areas, a spill or accidental release may occur anywhere in the University. The University maintains a hazardous materials spill response policy and procedures, and ensures their compliance with all federal, provincial, and municipal legislation concerning occupational health and safety and the protection of the environment. More details can be found on the Emergency Management webpage.

Spills can be categorized as either incidental (minor) or emergency (major) spills. The following definitions are in accordance with the *Occupational Safety and Health Administration (OSHA)* of the *United States Department of Labor.* More details can be obtained on the OSHA website.

Incidental Spill (or Minor Spill): means a release of hazardous material which does not pose a significant safety or health hazard to employees in the immediate vicinity or to the employee cleaning it up, nor does it have the potential to become an emergency within a short time frame. Incidental spills are limited in quantity, exposure potential, or toxicity and present minor safety or health hazards to employees in the immediate work area or those assigned to clean them.

Emergency Spill (or Major Spill): means a release of hazardous material which poses a significant safety or health hazard to persons in the immediate vicinity:

- Due to the properties of hazardous materials (toxicity, volatility, flammability, explosiveness, corrosiveness, etc.) and/or;
- Due to the particular circumstances of the release (quantity, location, space considerations, availability of ventilation, heat and ignition sources, etc.).

17.4.1. Incidental Spill (or Minor Spill)

Incidental spills can often be safely cleaned up by staff or students. However, anyone who is not a member of the University Spill Response Team and who is about to clean up an incidental spill must:

- Stay within their comfort zone.
- Be familiar with the hazards of the spilled material.
- Have clean-up instructions available on the MSDS.
- Use appropriate PPE and necessary clean up equipment.

If these requirements are met, staff or students can proceed with the following spill clean-up procedure:

1) Advise and warn co-workers located in spill area.
2) Ensure no one enters the spill area.
3) Consult the MSDS.
4) Don appropriate PPE.
5) Clean the spill & appropriately decontaminate the area.
6) Report the spill:
    - Notify your Supervisor
    - Complete an Injury/Near-Miss Report Form
    - Submit the Injury/Near-Miss Report Form to EHS

17.4.2. Emergency Spill (or Major Spill)

Emergency spills require higher level of precautions and training. They should only be cleaned up by the University Spill Response Team.

Anyone facing or witnessing an emergency spill must:

1) Advise and warn co-workers located in spill area.
2) Evacuate the area immediately.
3) Not touch or try to clean up the hazardous material spill.
4) Notify Security at x3717 or 514-848-3717.
5) Provide Security with the following information:
    - Location of the spill
    - Name of hazardous material
    - Quantity involved
    - Related health hazards and precautions to be taken
6) Provide Material Safety Data Sheet (MSDS) or appropriate documentation.
7) Remain available to the University Spill Response Team or Security in order to provide assistance.

17.4.3. Spill Kits

Spill kits and materials should be readily available for staff or students who want to clean up minor spills. Kits or spill cleanup materials should be:

- Located where the hazardous material is being used (e.g. laboratory).
- Available from the Department or Department Safety Officer (or Technical Officer).

Typical spill kit contents are listed in **Appendix V**.

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Appendix I : Template of Training Record

TEMPLATE OF TRAINING RECORD

UNIVERSITÉ Concordia UNIVERSITY **ENVIRONMENTAL HEALTH AND SAFETY**

TRAINING ATTENDANCE / COMPLIANCE RECORD

TRAINING/ ACTIVITY TITLE: _____

TRAINER: _____

DEPARTMENT: _____

COMPANY: _____

- Training with evaluation ☐
- Training without evaluation ☐
- Self-Training ☐
- Seminar ☐
- Safety Talk ☐
- Coaching/Monitoring ☐
- Proof from Other Institution ☐
- Other activity ☐

Date:	Time:	Duration: (minutes):	Location:	Expiration Date:

DESCRIBE KEYPOINTS OR ATTACH TRAINING DOCUMENT: _____

LAST Name, FIRST Name	ID NUMBER	E-MAIL	DEPARTMENT	SUPERVISOR	SIGNATURE

TRAINING CODE: SESSION ID: EHS Processed by: Date:

EHS-FORM-032 v.2

PLEASE RETURN COMPLETED FORM TO EHS – via Internal Mail GM 1100-50 or E-Mail ehs@concordia.ca

This form is also available in French on EHS website.

Back to section 4.6.

Appendix II: Segregation of Incompatible Chemical Classes

Group	Name	Example	Incompatible Groups
Group 1	Inorganic Acids	Hydrochloric acid Hydrofluoric acid Hydrogen chloride Hydrogen fluoride Nitric acid Sulfuric acid Phosphoric acid	2,3,4,5,6,7,8,10,13,14,16,17,18,19,21,22,23
Group 2	Organic acids	Acetic acid Butyric acid Formic acid Propionic acid	1,3,4,7,14,16,17,18,19,22
Group 3	Caustics	Sodium hydroxide Ammonium hydroxide solution	1,2,6,7,8,13,14,15,16,17,18,20,23
Group 4	Amines and Alkanolamines	Aminoethylethanolamine Aniline Diethanolamine Diethylamine Dimethylamine Ethylenediamine 2-Methyl-5-ethylpyridine Monoethanolamine Pyridine Triethanolamine Triethylamine Triethylenetetramine	1,2,5,7,8,13,14,15,16,17,18,23
Group 5	Halogenated Compounds	Allyl chloride Carbon tetrachloride Chlorobenzene Chloroform Methylene chloride Monochlorodifluoromethane 1,2,4-Trichlorobenzene 1,1,1-Trichloroethane Trichloroethylene Trichlorofluoromethane	1,3,4,11,14,17
Group 6	Alcohols Glycols Glycol Ether	1,4-Butanediol Butanol (iso, n, sec, tert) Diethylene glycol Ethyl alcohol Ethyl butanol Ethylene glycol Furfuryl alcohol Isoamyl alcohol Methyl alcohol Methylamyl alcohol Propylene glycol	1,7,14,16,20,23

Group 7	Aldehydes Acetaldehyde	Acrolein Butyraldehyde Crotonaldehyde Formaldehyde Furfural Paraformaldehyde Propionaldehyde	1,2,3,4,6,8,15,16,17,19,20,23
Group 8	Ketones	Acetone Acetophenone Diisobutyl ketone Methyl ethyl ketone	1,3,4,7,19,20
Group 9	Saturated Hydrocarbons	Butane Cyclohexane Ethane Heptane Paraffins Paraffin wax Pentane Petroleum ether	20
Group 10	Aromatic Hydrocarbons	Benzene Cumene Ethyl benzene Naphtha Naphthalene Toluene Xylene	1,20
Group 11	Olefins	Butylene 1-Decene 1-Dodecene Ethylene Turpentine	1,5,20
Group 12	Petroleum Oils	Gasoline Mineral Oil	20
Group 13	Esters	Amyl acetate Butyl acetates Castor oil Dimethyl sulfate Ethyl acetate	1,3,4,19,20
Group 14	Monomers Polymerizable Esters	Acrylic acid Acrylonitrile Butadiene Acrylates	1,2,3,4,5,6,15,16,19,20,21,23
Group 15	Phenols	Carbolic acid Cresote Cresols Phenol	3,4,7,14,16,19,20
Group 16	Alkylene Oxides	Ethylene oxide Propylene oxide	1,2,3,4,6,7,14,15,17,18,19,23
Group 17	Cyanohydrins	Acetone cyanohydrin Ethylene cyanohydrin	1,2,3,4,5,7,16,19,23

Group 18	Nitriles	Acetonitrile Adiponitrile	1,2,3,4,16,23
Group 19	Ammonia	Ammonium Hydroxide Ammonium Gas	1,2,7,8,13,14,15,16,17,20,23
Group 20	Halogens	Chlorine Fluorine	3,6,7,8,9,10,11,12,13,14,15,19,21,22
Group 21	Ethers	Diethyl Ether THF	1,14,20
Group 22	Phosphorus	Phosphorus, Elemental	1,2,3,20
Group 23	Acid Anhydrides	Acetic anhydride Propionic anhydride	1,3,4,6,7,14,16,17,18,19

Back to section 7.4.2

Appendix III: Peroxide forming chemicals and solvents

Class III

Chemicals that form explosive levels of peroxides without a concentration step, e.g., evaporation, distillation, etc., are listed below. These chemicals can be a particular hazard since peroxides can form even without opening the containers. Therefore, only small amounts should be ordered and used as soon as possible. If stabilizers are present in solution, they can be kept for up to one year or up to the manufacturer's expiration date where appropriate. With no stabilizer present, they should not be kept for over three months after opening. When possible, store these chemicals under a nitrogenblanket.

Butadiene (when stored as a liquid monomer)
Chloroprene (when stored as a liquid monomer)
Diisopropyl ether
Divinyl acetylene
Divinyl ether
Isopropyl ether
Potassium amide (Inorganic Peroxide Former)
Sodium amide (Inorganic Peroxide Former)
Sodamide (Inorganic Peroxide Former)
Tetrafluoroethylene (When Stored as a Liquid Monomer)
Vinylidene chloride.

Class II

Chemicals that form explosive levels of peroxides upon concentration are listed below. These chemicals typically accumulate hazardous levels of peroxides when evaporated, distilled, contaminated, or have their peroxide inhibiting compounds compromised. After receiving, they should not be kept past 12 months or the manufacturer's expiration date. After this period, the product must be disposed.

Acetal
Acetaldehyde
Benzyl alcohol
Butadiyne
2-Butanol
Cellosolves
Chlorofluoroethylene
Cumene
Cyclohexene
Cyclohexanol
2-Cyclohexen-1-ol
Cyclooctene
Cyclopentene
Decahydronaphthalene
Decalin
Diacetylene
Dicyclopentadiene
Diethyl ether
Diethylene glycol
Diglyme (Dimethyl ether)
Dioxanes
Ethyl ether
Ethylene glycol dimethyl ether
Ethylene glycol ether acetates
Furan
Glyme
4-Heptanol
2-Hexanol
Isopropyl alcohol
Isopropylbenzene
Methyl acetylene
3-Methyl-1-butanol
Methyl cyclopentane
Methyl isobutyl ketone
4-Methyl-2-Pentanol
4-Methyl-2-Pentanone
2-Methyltetrahydrofuran
2-Pentanol
4-Penten-1-ol
1-Phenylethanol
2-Phenylethanol
2-Propanol
Tetrahydrofuran
Tetrahydronaphthalene
Tetralin
Vinyl ethers

Class I

Chemicals that may auto polymerize as a result of peroxide accumulation are listed below. These chemicals can undergo hazardous polymerization reactions that are initiated by peroxides that have accumulated in solution. They are typically stored with polymerization inhibitors to prevent these dangerous reactions. Inhibitors do become compromised over time however, and thus after receiving, these chemicals should not be kept for over 12 months or the manufacturer's expiration date. Non-inhibited chemicals should not be opened and stored over 24 hours. Non-inhibited chemicals should be inhibited with the appropriate compounds before the 24-hour mark is exceeded. Do not store inhibited chemicals in this category under an inert atmosphere because some of the inhibitors require a small amount of oxygen to work.

Acrylic acid
Acrylonitrile
Butadiene
Chlorobutadiene
Chloroprene
Chlorotrifluoroethylene
Dibenzocyclopentadiene
9,10-Dihydroanthracene
Indene
Methyl methacrylate
Styrene
Tetrafluoroethylene
Vinyl acetate
Vinyl acetylene
Vinyl chloride
Vinyl pyridine

Appendix IV: [Flammable or Toxic] Compressed and Liquefied Gases

COMPRESSED AND LIQUEFIED GASES FLAMMABLE OR TOXIC (NFPA HEALTH 3 OR 4)

Gas	State	Flamm*	Health	Gas	State	Flamm*	Health
Acetylene	Gas	Y		**Hydrogen Bromide**	Gas	N	3
Allene (Propanediene)	Liquid	Y		**Hydrogen Chloride**	Gas	N	3
Ammonia	Liquid	Y	3	**Hydrogen Cyanide**	Liquid	Y	4
Arsine	Liquid			**Hydrogen Fluoride**	Gas	N	4
Boron Trichloride	Gas	N	3	**1,1-Difluoroethane**	Liquid	Y	
Boron Trifluoride	Gas	N	3	**Hydrogen Selenide**	Liquid	Y	3
1,3-Butadiene	Liquid	Y		**Hydrogen Sulfide**	Liquid	Y	4
n-Butane	Liquid	Y		**Ketene**	Gas	Y	
iso-Butane	Liquid	Y		**Methane**	Gas	Y	
1-Butene	Liquid	Y		**Methylacetylene (Propyne)**	Liquid	Y	
2-Butene	Liquid	Y		**Methylamine**	Liquid	Y	3
Carbon Monoxide	Gas	Y	3	**Methylbromide**	Liquid	Y	3
Carbonyl Chloride (Phosgene)	Gas	N	4	**3-Methyl-1-butene**	Liquid	Y	
Carbonyl Fluoride	Gas	N	4	**Methyl chloride**	Liquid	Y	
Carbonyl Sulfide	Liquid	Y	3	**Methyl ether**	Gas	Y	
Chlorine	Gas	N	3	**Methyl Fluoride**	Liquid	Y	
Chlorine Dioxide	Gas	N	4	**Methyl Mercaptan**	Liquid	Y	4
Chlorine Monoxide	Gas	Y	3	**2-Methylpropene**	Gas	Y	
Chlorine Trifluoride	Gas	N	4	**Natural Gas**	Gas	Y	
1-Chloro-1,1-difluoroethane	Liquid	Y		**Nitric Oxide**	Gas	N	3
Chlorotrifluroethylene	Liquid	Y		**Nitrogen Dioxide**	Gas	N	3
Cyanogen	Liquid	N	4	**Nitrogen Trioxide**	Gas	N	3
Cyanogen Chloride	Liquid	N	4	**Nitrosyl Chloride**	Gas	N	3
Cyclobutane	Gas	Y		**Oxygen Difluoride**	Gas	N	4
Cyclopropane	Liquid	Y		**Ozone**	Gas	N	4
Deuterium	Gas	Y		**Pentaborane**	Liquid	SI	4
Diazomethane	Gas	Y	4	**Iso-Pentane**	Liquid	Y	
Diborane	Gas	SI	3	**Phosphine**	Gas	SI	4
1,1-Difluoroethane	Liquid	Y		**Propane**	Liquid	Y	
Dimethylamine	Gas	Y	3	**Propylene**	Liquid	Y	
Dimethyl Ether	Liquid	Y		**Selenium Hexafluoride**	Gas	N	3
2,2-Dimethylpropane	Liquid	Y		**Silane**	Gas	SI	
Ethane	Gas	Y		**Silicon Tetrafluoride**	Gas	N	4
Ethylacetylene	Liquid	Y		**Stibine**	Gas	Y	4
Ethyl Amine	Liquid	Y	3	**Sulfur Tetrafluoride**	Gas	N	4
Ethyl Chloride	Liquid	Y		**Sulfuryl Fluoride**	Gas	N	
Ethylene Oxide	Liquid	Y	3	**Tetrafluoroethylene, monomer**	Liquid	Y	
Fluorine	Gas	N	4	**Tetrafluorohydrazine**	Liquid	Y	
Formaldehyde	Gas	Y	3	**Trimethylamine**	Liquid	Y	3
Germane	Gas	Y		**Vinyl Bromide**	Liquid	Y	
Hexafluoroacetone	Gas	N	3	**Vinyl Chloride**	Liquid	Y	
Hydrogen	Gas	Y		**Vinyl Fluoride**	Liquid	Y	

* : Flamm: Flammable, Y = Yes; N= No; SI = Spontaneously ignite

Appendix V: Typical Laboratory Spill Kits

Typical Laboratory Chemical Spill Kit

Items	Purpose / Details
Polypropylene or high-density polyethylene bucket with top (5-gallon size or larger)	To act as a receptacle for chemical resistant bag liners during a spill clean-up and as a storage container for the spill kit components.
Chemical resistant bags	All spill residue and spill clean-up material should be placed in a high density polyethylene or polypropylene bag. These bags should be made of strong construction: • Leak proof • 4mil in thickness
Personal protective equipment (PPE) At least: • 2 pairs of chemical splash goggles • 2 pairs of disposable nitrile gloves • 2 pairs of heavy gauge, long cuff nitrile, Neoprene or butyl rubber gloves • 2 Tychem® coveralls (L or XL) • 2 pairs chemical resistant shoe covers • 2 disposable masks (N95)	No gloves are totally chemical-proof; however, some are more resistant to chemicals than others. Latex gloves are not resistant to most laboratory chemicals and should not be in the spill kit.
Universal hazard absorbent pads	High Capacity Chemically inert Absorbs aggressive chemicals as well as non-aggressive compounds such as water Good for all chemicals: • Acids • Bases • Flammable liquids • Formaldehyde • Organic peroxides
Plastic clean-up tools (dust pan or scoop and brush, etc.)	For solid chemical spills. Should be chemical resistant and non-sparling (non-static). A variety of polypropylene tools are available.
EHS chemical waste labels	To properly identify spill waste.
Neutralizing and treatment materials (only if strong acids/bases are used)	Type and quantity are dependent on the laboratory's chemicals: • Acid and/or base neutralizer • 1 roll of pH paper
Mercury spill kit (optional)	Only if possibility of mercury spill in laboratory.
A copy of all applicable chemical spill procedures or SOP	

Typical Laboratory Biological (Biohazardous) Spill Kit

Items	Purpose / Details
Autoclave bags	For collecting biologically contaminated materials during the cleanup.
Personal protective equipment (PPE) At least: • 2 pairs of chemical splash goggles • 2 pairs of disposable gloves • 2 disposable gowns or lab coats (size L or XL) • 2 pairs chemical resistant shoe covers • 2 disposable masks (N95)	Latex, vinyl or nitrile gloves should be available in multiple sizes. Disposable N95 masks protect from direct (splash) and indirect (accidental transfer via hands) contact with infectious material or toxins during spill cleanup. If fit-tested, N95 masks also provide protection from aerosols.
Absorbent materials	Absorbent materials can be: • Paper towels or absorbent pads • High-absorbency paper towels (such as Wypalls) • Micro-encapsulation absorbent (e.g., BioSorb, SafeGuard Absorbent, Safetec EZ Cleans Kit, etc.)
Plastic clean-up tools, for example: • Polypropylene brush and dustpan or scoop • Tweezers or forceps	• Polypropylene plastic can be autoclaved • For collecting contaminated materials such as broken glass/sharps
Effective concentrated chemical disinfectant	• *Consult your SOP to find the proper procedure.* • Dilute immediately before use, e.g., if chlorine bleach is appropriate, dilute household bleach (~5% sodium hypochlorite) to 1/10. • Replace yearly to ensure efficacy
Sharps container	
A copy of all applicable biological spill procedures or SOP	

Typical Laboratory Nuclear Substance Spill Kit

Items	Purpose / Details
Polypropylene or high-density polyethylene bucket with top (5-gallon size or larger)	To act as a receptacle for bag liners during a spill clean-up and as a storage container for the spill kit components. Thickness of pail can better block radiations than plastic bags solely.
Chemical resistant bags	All spill residue and spill clean-up material should be placed in a high density polyethylene or polypropylene bag. These bags should be made of strong construction: • Leak proof • 4mil in thickness
Chalk, wax pencil or tape	To clearly mark or delimitate radioactive spill area.
Personal protective equipment (PPE) At least: • 2 pairs of chemical splash goggles • 2 pairs of disposable nitrile gloves • 2 disposable gowns or laboratories coats (L or XL) • 2 pairs chemical resistant shoe covers • 2 disposable masks (N95)	No gloves are totally chemical-proof; however, some are more resistant to chemicals than others.
Universal hazard absorbent pads	High Capacity and chemically inert. Absorbs aggressive chemicals as well as non-aggressive compounds such as water.
Decontamination solution and scrub brush	General cleaner/detergents such as RadCon spray or similar foaming spray. A scouring powder, scrub brush can also be used for a more aggressive decontamination.
Forceps or tongs	For safe handling of any sharps.
Radioactive waste labels	Label “Radiation – Danger – Rayonnement” with radiation logo to properly identify radioactive spill waste.
Wipe testing kit	Filter papers and liquid scintillation vials for wipe test.
Contamination meter	Mainly for gamma and energetic beta emitters (e.g. P^{32}, Tc^{99m} or F^{18})
A copy of all applicable radioactive spill procedures or SOP	