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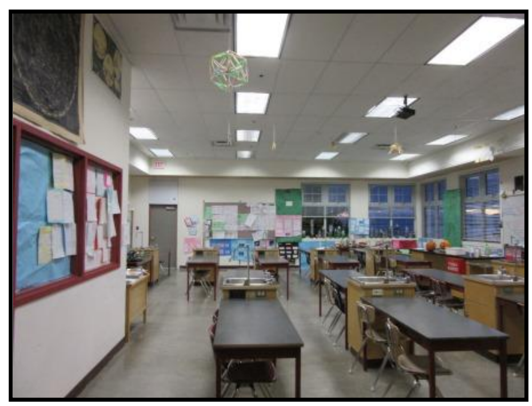
SCHOOL SCIENCE LAB
SAFETY MANUAL



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Section 1

School Science Lab Safety Program

The purpose of a safety program is to insure a safe environment exists in every school science lab or classroom. The safety program is designed to prevent injuries to students and teachers.

The teacher is responsible for the training of safe practices in their science lab classroom.

Subsequently, if a student is not trained on specific science lab equipment, or is thought to be a safety concern for others, then a student should not be allowed to operate in a science lab or classroom.

The safety program consists of more than lecturing and posting of safety rules and regulations. It includes active instruction that involves the student in learning and choosing behaviours that promote the safe use of equipment and procedures within an active science lab or classroom environment.

The following factors are a short list of injury prevention criteria:

- Ample space is provided for experiments and equipment;
- Permanently placed equipment is fastened to the floor or work area;
- Safety areas are clearly marked when experiments are taking place;
- Approved personal protection equipment ("PPE") is worn when required;
- Standard emergency stations are provided;
- All safety procedures are followed at all times;
- Standard storage is provided for chemicals, compressed gases and flammable liquids;
- Students are not allowed in designated preparation areas;
- Full safety training is provided on all equipment before first use; and
- Enforcement policies are provided which allow teachers to remove students from school science labs and classrooms if they are thought to be a danger to the teacher or other students.

Section 2

Source Materials, Standards, Codes and Recommended Practices

The purpose of this manual is to discuss the safe and recommended practices for school science labs and classrooms' design and safety. The information in this manual includes various source materials in regard to school science labs and classrooms.

- Provincial Building Codes;
- Provincial Fire Codes;
- 1952 BC School Building Manual;
- 1986 – 1992 BC School Building Manual;
- British Columbia – BC Science Safety Resource Manual;
- Alberta – Safety in the Science Classroom;
- Saskatchewan Schools – Science Lab Safety;
- Manitoba Education – Science Safety;
- WorkSafeBC & OSHA Standards; and
- Other related standards, regulations and documentation.

Section 3

Responsibilities of District, Staff and Students

The responsibility for every level of operation within the school district in regard to safety in and around school science labs should follow the basic ideas and recommended practices as discussed in the WorkSafeBC recommended practices.

The division and/or maintenance department is responsible to ensure they provide a safe work place for the staff and teachers.

The teachers are responsible for providing training, direction and supervision to students to help mitigate potential harm to the students.

The students are required to follow all the rules and regulations within the school science labs and classrooms and should ask questions if they have any concerns in regard to safety or operations.

Expanded responsibilities are discussed further below, including the following:

- General Responsibilities
- Employer (School District / Maintenance Department)
- Supervisor (Science Lab Teacher)
- Worker (Student)

GENERAL RESPONSIBILITIES

- Educators have a responsibility to both students and their parents to provide a safe learning environment, in which the risk of personal injury is low. For science educators, however, this responsibility is compounded by the fact that students generally have little to no experience working in hazardous environments where the knowledge of risks and the need for safe work practices are crucial.
- Safety in the school science labs and classrooms is everyone's business.
- The following is a list of responsibilities adapted from the Workers' Compensation Board in their WorkSafeBC online document entitled "Safety on the Job is Everyone's Business: The Responsibilities of Employers, Supervisors, and Workers", at their website: **www.WorkSafeBC.com/en/resources/health-safety/books-guides/safety-on-the-job-is-everyones-business-the-responsibilities-of-employers-supervisors-and-workers?lang=en)**

EMPLOYER (SCHOOL DISTRICT / MAINTENANCE DEPARTMENT)

- To provide a safe environment;

- Take action immediately when a student or science lab teacher tells you about a potentially hazardous situation;
- Initiate an immediate investigation into accidents;
- Report serious staff accidents to WCB; report student accidents to the school district office and the schools protection programs;
- Provide adequate first aid facilities and services; and
- Provide personal protective equipment where required.

SUPERVISOR (SCIENCE LAB TEACHER)

- Instruct new students in safe work procedures;
- Train students for all tasks assigned to them and check their progress;
- Ensure that only authorized, adequately trained students perform experiments and operate equipment;
- Enforce safety regulations;
- Correct unsafe acts and conditions;
- Identify students with problems (e.g. drugs or alcohol) that could affect their safety and the safety of others; follow up with interviews and referrals where necessary;
- Formulate safety rules and inspect for hazards in your own area;
- Keep accurate safety and training records; and
- Complete a school protection program incident report each time an accident occurs.

WORKER (STUDENT)

- Know and follow safety and health procedures affecting your work;
- If you do not know, ask for training before you begin;
- Work safely and encourage your classmates to do the same;
- Correct or immediately report any unsafe conditions to your teacher; and
- Take the initiative to make suggestions for improved safety conditions.

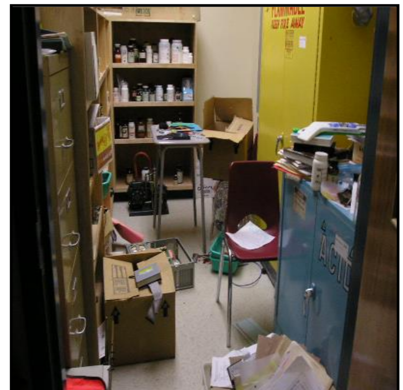
Section 4

Setting Up and Maintaining a Safe Science Lab

ACHIEVING A SAFE FACILITY

The intent of this section is to help the teacher achieve and maintain a safe facility. Topics in this section include:

- Safety and Health Inspections
- Hazard Analysis



PURPOSE OF SAFETY AND HEALTH INSPECTIONS

To provide the teacher with an understanding of the inspection process and give them the ability to carry out effective safety and health inspections. The following will introduce:

- Purpose of inspections
- Types of inspections
- Persons involved in the inspection process
- Techniques
- Methods of recording

INTRODUCTION

Safety and health inspections are an important part of the hazard control process. Regular inspections play an important part in providing a safe environment for our students.

MANDATORY INSPECTIONS

Every school facility and each of its processes and operations contain potential hazards which come about through normal use, or through changes and/or additions of new equipment. One way of remaining aware of hazards is through continuous inspections.

PURPOSE OF INSPECTION

Inspections should be performed every day for the following reasons:

- To spot potential hazards before an incident occurs;
- To assess the hazard; and
- To identify improvements and make corrections to improve overall operations and increase effectiveness.

INSPECTIONS MAY BE CLASSIFIED AS PERIODIC OR CONTINUOUS

Periodic Inspection
A safety and health inspection is thorough and systematic. These inspections can be conducted monthly or bi-monthly. This type of inspection covers all areas (e.g. operations, equipment, etc.).

Continuous Inspection
Continuous inspections should be conducted by students, teachers, department heads or supervisors as part of their instructional, supervisory, or assigned duties. Continuous inspections provide an immediate chance to examine, and if necessary to correct (or to report if correction is not possible) any unsafe situations.

WHO SHOULD PERFORM THE INSPECTIONS

Teachers
Teachers must make continuous inspections and be aware of changing conditions, operations and work methods. These inspections may have to be made several times a day (i.e. at the beginning of each day, and for certain equipment, at the beginning of each class).

Students
Student inspections allow students to take a major role in their shop / lab / facility, thus giving them a sense of ownership.

Department Head or Supervisors
A school or school division that has a department head or supervisor for science labs and equipment has a further advantage in safety and health inspections. The department head or supervisor should record any unsafe conditions and practices and forward the information to the teacher and/or maintenance personnel if required.

INSPECTION PROCEDURES
An inspection program requires that those conducting the inspections:

- Have a sound knowledge of the facility;
- Have systematic inspection process for the facility; and
- Have a method of reporting, evaluating and using the data gathered.

USING A HEALTH AND SAFETY CHECKLIST
There are many different types of checklists available for the use in safety and health inspections, varying from thousands of items to just a few. Each type has its place, and when properly used can benefit the particular facility (see Appendix "D").

BE THOROUGH
Any checklist for use in safety and health inspections is only as good as the method in which it is completed. The checklist is to be used as an aid in the inspection process, keeping in mind other items may have to be recorded. Any observed hazard must be recorded even though it may not be on the list.

WHAT SHOULD BE INSPECTED

When inspecting, the following should be considered:

- Materials and Substances: Inspect those materials and substances that may cause injury, illness, fire, or other hazards.
- Chemicals, Equipment and Ventilation: Ensure that they are free of defects and other hazards. Make sure chemical storage, equipment (condition) and exhaust systems are in place.
- Personal Protective and Safety Equipment: Ensure that there is adequate protection for all students involved and that the equipment is in good shape (i.e. safety glasses/shields are free from scratches; protective wear is free of holes).

- Working and Walking Areas: Areas must be clean and functioning safely.
- Environmental Factors: Ensure lighting, ventilation and chemical control equipment is up to standards.
- Housekeeping: Material storage, waste disposal, floor and counters should be neat and tidy.
- First Aid Kit and Eyewash/Shower Station: Ensure the first aid kit is stocked with adequate supplies and the eyewash station / shower station is functioning properly.
- Electrical: Switches, breakers, fuses, cords and plugs must be in compliance with regulations.

CHEMICAL STORAGE, HANDLING AND USE

Ensure that material such as paints are stored properly (i.e. chemicals, flammable liquids, acids, etc. should be stored in an approved cabinet). Specific protective clothing should be available for the chemical requirements. Adequate exhaust ventilation must be in place where stated by chemical requirements.

FIRE PROTECTION AND EXTINGUISHING SYSTEMS

Fire blanket, fire extinguishers, fire exit doors, fire exit signs, etc. must all be in good order and in clear working condition.

PREVENTATIVE MAINTENANCE

The teachers should provide consistent preventative maintenance in the lab/facility and tools that will help ensure incident prevention and student safety.

HAZARD ANALYSIS

The benefit of hazard analysis is to increase the awareness of potential hazards.

Results of Hazard Analysis
Hazard analysis should help to:

- Improve instructional quality;
- Assist in the selection of processes and tasks;
- Create awareness of possible incidents;
- Establish control measures (special procedures, guarding, PPE);
- Set up equipment and machinery so that students or the teacher will not be exposed to unnecessary hazards;
- Identify situational hazards in facilities (equipment, tools, materials);
- Identify human factors responsible for incidents (student capabilities, activities and imitations);
- Identify exposure factors that contribute to injury and illness (contact with hazardous substances and materials); and
- Determine safe inspection methods and maintenance standards.

Who Should Participate in Hazard Analysis
The teacher may initiate the analysis of the processes, operations and tasks; however, others may also give assistance (i.e. department heads, maintenance personnel, colleagues, manufacturing representatives and students).

Note: Remember to review specific equipment manuals for proper procedures.

What to Analyze
There are many processes, operations and tasks conducted that have potential hazards.

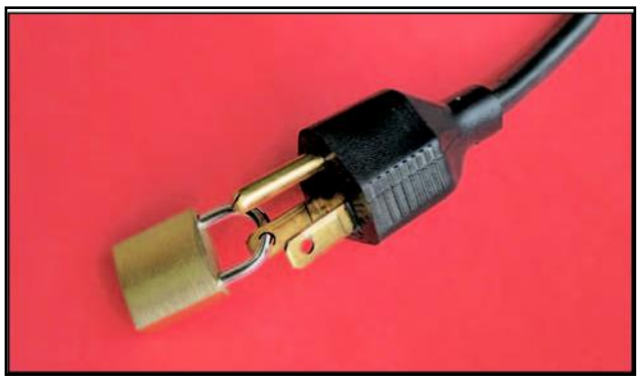
Consideration should be given to:

- General housekeeping;
- Inappropriate use of tools and equipment;
- Faulty tools and equipment;
- New or altered processes;
- Potential for injury;
- Severity of injury; and
- Frequency of incidents.

The Process of Hazard Control
The four processes in hazard control are:

1. Spot the hazard;
2. Assess the risk;
3. Find a safer way; and
4. Practice all of the above every day.

Hazardous Equipment
In the process of inspection, various actions or corrections may have to take place. When a broken or damaged tool is found, the teacher should immediately take it out of service. Large equipment, however, may have to be properly tagged. The teacher may also need to perform an electrical lockout by placing a mini padlock through one of the tines of the power cord plug to prevent unauthorized use of the tool.



SUMMARY
Acting on the information gathered from an inspection is as important as conducting the inspection in the first place. It is necessary that the inspection team brings problems and recommendations for corrective action to the attention of those involved (i.e. teacher, principal, designated person or Workplace Safety and Health). Based on problems uncovered and recommendations received, they must then determine the best course of action.

Information from inspections should never be seen as a fault-finding or criticism, but rather as fact-finding with emphasis on locating potential hazards that may have an adverse effect on the safety of the operation. The information is simply the basis for establishing priorities and implementing programs that will improve conditions to provide a safe environment for our students.

Section 5

General Safety – Personal Protection Equipment ("PPE")

NOTE: The information available from various provincial and (WCB) WorkSafeBC sources should be used as the primary sources of information when discussing safe practices within the school science lab area.

The information discussed in this section can be used to enhance the Provincial and (WCB) WorkSafeBC sources, if required.

PPE does not take the place of such engineering controls as substitution, isolation and ventilation. PPE includes such items as helmets, glasses, goggles, face shields, special footwear, respirators, protective clothing and other items that protect the student against hazards such as flying particles, noise, chemicals, heat-producing devices, vapours and electric shock.

Sometimes the only practical way to reduce illness and injuries is to use personal protective equipment. The first method is to control the problem at its source; the second is to control it along the path. PPE is regarded as the last line of defense.

SELECTING PERSONAL PROTECTIVE EQUIPMENT (PPE)

- The extent of the hazard's potential to cause harm must be determined;
- The degree of desired protection is in direct proportion to the seriousness of the hazard;
- The equipment's ability to protect must be considered along with its potential to interfere with the students' work;
- Protective equipment, particularly for eyes and face, must be approved by the Canadian Standards Association (CSA); and
- Quality is an important factor to consider. Good protective equipment may not be inexpensive, but may last considerably longer than lower grade PPE.

PPE FIT

The PPE must fit the student. Poorly fitted protective equipment discourages students' acceptance and may hinder their work and safety.

EDUCATION

Unless students are educated in the use and care of PPE, it may do little to fulfill its intended purpose.

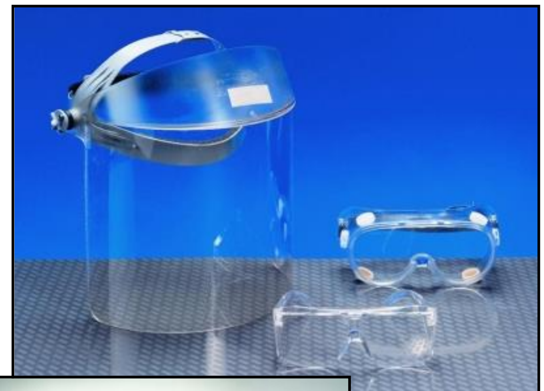
PPE REQUIREMENTS

Loose Hair Protection

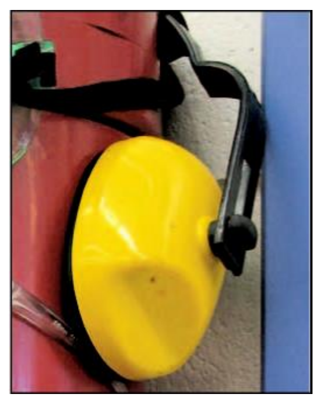
There is always a danger of hair becoming entangled in equipment, devices or being effected by chemicals and heat producing devices. Students with long hair should have their hair tied back, secured or tucked underneath their clothing.

Eye and Face Protection (CSA Z94.3 – Eye & Face Protection)
In school science labs, students' eyes can be exposed to a variety of hazards (i.e. chemical vapours, splashes of corrosive liquids, exposures to irritants, flammable fuels and harmful radiation). WorkSafeBC requires that eye and face protection be designed to meet standards.

The type of face shields, goggles and safety glasses used must meet their intended purpose. A variety of types and sizes of safety glasses give the student an opportunity to select his or her own "style". Glasses that are damaged by pitting or scratching must be replaced. A weekly check of their condition is essential.

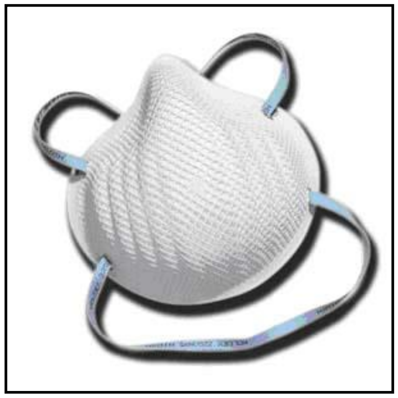



Hearing Protection (CSA Z94.2 – Hearing Protection Devices)
The need for hearing protection arises when source control and/or path control are not present, when source and/or path control do not lower noises to safe levels or when a person in the facility cannot avoid direct exposure to noisy equipment and devices.



Many types of personal hearing protection devices are available, ranging from ear plugs to cup-type hearing protectors. Selection of a protective device is governed by individual preference. Important factors to consider are effectiveness, comfort, and cost.

Respiratory Protection (CSA Z94.4 – Selection, Use and Care of Respirators)
The human respiratory system presents the quickest and the most direct avenue of entry of hazardous materials because it is connected with the circulatory system and the need to oxygenate tissue cells. Air may be contaminated with dusts, fumes and sprays. The most important objective is to prevent atmospheric contamination. This should be accomplished by engineering control measures (i.e. enclosure or confinement of operation, general and local ventilation, and substitution of less toxic material). When effective engineering controls are not feasible, appropriate respirators must be used.



Hand Protection (Based on Potential Exposures)
Statistics indicate injuries to the arms, hands, and fingers account for more than a quarter of all disabling mishaps. The hazards in science lab facilities are similar to those in the industry (i.e. chemicals, heat, sharp objects and corrosives).

Many science lab incidents are the result of handling materials or exposures to vapours, etc. PPE can do little to prevent incidents in these areas, but they can protect the student from initial exposure.

Gloves supplement good work practices to prevent hand injuries during the handling of chemicals and materials and during experiments. There are many types of gloves that are suitable for chemicals, radiation, heat and flame.

Body Protection (Based on Potential Exposures)
Students require protection from the hazards of splashing liquids, heat and chemicals.

Lab coats and protective clothing are designed to provide basic protection from various exposures that may be found in most high school science labs.

Section 6

Science Lab Safety Equipment

NOTE: The information available from various provincial and (WCB) WorkSafeBC sources should be used as the primary sources of information when discussing safe practices within the school science lab area.

The information discussed in this section can be used to enhance the Provincial and (WCB) WorkSafeBC sources, if required.

Here is what we will cover in this section of the manual:

Safety Equipment for Science Classrooms

Teachers, staff and students should be familiar with the location and use of all safety equipment located in a science lab classroom. The equipment should be stored in an easily accessible location and should be available at all times.

NOTE: Locations and use of safety equipment in science labs and science lab classrooms should be an important part of all safety training provided in these areas.

Recommended Practices

1. A standard documented Safety equipment inspection program should be developed.
2. An ongoing safety equipment inventory and use schedule should be maintained.
3. Standard ventilation should be provided for all Science Classrooms and Science Lab areas.
4. Safety equipment located in the Science Labs or Science Lab Classrooms should meet or exceed all recommended practices based on chemicals and materials used. As well as type of experiments and equipment to be used.

RECOMMENDED EQUIPMENT

Equipment	**Description**
Free standing clear plastic screen	Used for teacher demonstrations.
One pair heat resistant gloves	Gloves should be made of treated textured silica or woven fabric.
One eye wash station	Water supply must be tempered; documented testing is required once every month.
Emergency shower	Water supply must be tempered; documented testing is required once every month.
Fire blanket	Used for smothering clothing fires; should be a combination fire-proofed wool/rayon fabric.
Minimum of one ULC listed 2A10BC fire extinguisher	Fire extinguisher should be visually inspected at a minimum of once every month.
Sand bucket (approx. 20 L of sand) *NOTE: May replace with Class D type*	For small fires and combustible metal fires only.

fire extinguisher if required	
One pair of safety goggles or face shields for each person taking part in experiments or demonstrations	Eye and face protection must meet or exceed all CSA standards. Standard goggles are preferred, as they provide more complete protection.
Lab coats	Should be worn whenever there is a possibility of contact with chemicals.
One respirator or mask per teacher, person or demonstrator, as required	Respirators or masks should be used based on expected and possible exposure, including but not limited to vapours, mist, dust and other potential exposure.
One pair of safety/beaker tongs	Tongs should be used with heat resistant gloves.
One fume hood	The fume hood should provide standard air velocity and extraction as required by designated standards.
Experimental sinks	To be used for specific types of experiments.
Hand washing facilities	Should be separate from sinks used in conjunction with experiments.
Spill kits	Used to absorb chemical and other spills in the science lab or science classroom.
Waste disposal of glass	Broken glass can be disposed of in designated containers.
Waste disposal of organic solvents and soluble chemicals	Organic solvents and flammable waste must be collected in separate, tightly covered, labeled containers, and should be disposed of based on municipal, provincial and federal regulations.
Waste disposal of biological matter	Biological waste must be segregated and disposed of safely; municipal, provincial and federal rules may apply.
ULC approved self-closing waste container	For disposal of items that are soiled or contaminated with flammable chemicals or materials.
Neutralizing solutions	Dependent upon chemicals being used; may require small amounts of neutralizing solutions in the event of spills.
Laboratory first aid kit	Should contain all of the items as recommended in "BC Science Safety & Resource Manual" and/or local WCB regulations.
Chemical resistant rubber gloves, dustpan, brush, garbage bags and other cleaning items	To be used for cleaning up areas in and around the science lab and classroom.

SAFETY STATION REQUIREMENTS

This information in regard to minimum safety station recommended practices was taken from various OH&S sources, WorkSafeBC sources, and others:

- Eyewash station (ANSI Z358.1 – Emergency Eye Wash and Showers)
- Emergency shower (ANSI Z358.1 – Emergency Eye Wash and Showers)
- Water cut-off switch
- Gas cut-off switch
- Fire proof cabinet containing first aid kit, safety manual and safety goggles
- Fire extinguisher (ABC)
- Fire blankets
- Spill/clean-up kits
- List of emergency response procedures
- Intercom/communication to general office

Section 7

Science Lab Facility

NOTE: The information available from various provincial and (WCB) WorkSafeBC sources should be used as the primary sources of information when discussing safe practices within the school science lab area.

The information discussed in this section can be used to enhance the provincial and (WCB) WorkSafeBC sources, if required.

Here is what we will cover in this section of the manual:

- Recommended (Sample) Facility Layout and Equipment
- Facility Design and Safety Equipment

RECOMMENDED (SAMPLE) FACILITY LAYOUT AND EQUIPMENT

Facility considerations when designing a science lab and classroom:

1. Science labs and classroom activities generally require a flat, horizontal work space.
2. To help ensure proper supervision is provided, the classroom and lab space should be designed to allow the instructor to have clear, unobstructed sight lines to all students.
3. The number of students that may safely work in a science lab or classroom should be determined and governed by local fire and building code regulations. The recommended gross space allocated in the classroom is 4.6 sq.m. per person.
4. If the work area is found or appears to be congested, there may be a need to perform a risk analysis of the work area to ensure it does not prove to be hazardous in design.
5. Science lab areas and classrooms should be provided with standard and regulated storage cabinets, cupboards, storage rooms, chemical and wash sink areas, emergency equipment areas, and designated chemical storage areas, etc.
6. All science labs and classrooms should be adequately ventilated.
7. When designing or redesigning a designated science lab or classroom, all areas and information as discussed should be taken into consideration. The primary focus should be to provide a safe, clean work environment that meets the needs of teachers, staff and students.

Facility Design and Safety Equipment

The following checklists are provided as a guideline only. Further information (if required) is available through provincial, (WCB) WorkSafeBC and OSHA guidelines and standards.

Layout and Space

- ☐ Does the room have adequate space?
- ☐ Is the aisle width adequate to accommodate equipment and students with physical disabilities (1.2 to 1.5 metres)?
- ☐ Is the workspace per student adequate?
- ☐ Can the teacher see students in all locations of the room?
- ☐ Is the general light level sufficient (538.2 to 1076.4 lumens per square metre, with diffuse lighting preferred)?

Safety Equipment

- ☐ Is a telephone or intercom available in case of emergencies?
- ☐ Are fire and heat detectors installed in laboratories, science preparation rooms, chemical storage areas, waste disposal areas, and any other high-risk areas?
- ☐ Is there at least one emergency eyewash station located in areas where corrosive chemicals are used, according to OH&S regulations for workers?

Exits

- ☐ Does the room have two exits (both with doors that open outward) which have reinforced glass viewing windows or peepholes?
- ☐ Do the doors open easily with standard exit hardware provided?
- ☐ Are doorway widths sufficient to accommodate students with physical disabilities, allow movement of equipment carts and serve as emergency exits?

Construction Materials

- ☐ Are ceilings constructed out of material with a low flame-spread rating (i.e. drywall)?
- ☐ Are floors even, free of cracks and have non-skid surfaces (sheet flooring is preferable to tile or carpet; tile floors should be covered with a non-skid wax)?
- ☐ Are bench surfaces made of material resistant to acids, alkalis, solvents and heat?

Ventilation

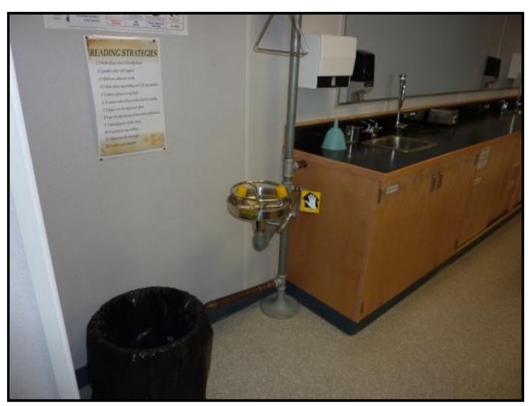
- ☐ Is air in the room recycled and mixed with outside air at a rate of 4 to 12 complete laboratory air changes per hour (depending on the chemicals used), or a minimum of 15L per second per occupant?
- ☐ Is the exhaust ventilation system separate from that of the chemical fume hood?
- ☐ Is the exhaust ventilation system hood(s) located away from doorways, windows, high traffic areas, or areas with disrupted airflow?
- ☐ Installation of chemical fume hoods in science rooms are governed by various provincial, WCB and OSHA regulations and recommended practices. They are recommended for senior high school chemistry laboratories and rooms where chemicals are prepared. Where fume hoods exist, the functional and maintenance standards that apply are those of the American National Standards Institution. These include an average face velocity of at least 0.5 m/s and all individual face velocity readings must be above 0.43 m/s. Exhaust is vented to the outside wall or roof vent.

Electrical

- ☐ Are there sufficient electrical outlets (i.e. located at intervals of 2 to 2.5 metres) to make extension cords unnecessary; and have all power outlets met local electrical code standards? Where hot plates will typically be in use, it is recommended that each 15 amp circuit be restricted to two double plug-in outlets, to prevent overload and tripping of breakers during times of maximum usage.
- ☐ Are any outlets within 1.5 metres of water equipped with ground-fault interrupters?
- ☐ Are fume hood controls located outside the fume hood in an immediately accessible area?

Plumbing

- ☐ Is plumbing free of leaks or cracks; and are drains made of chemical resistant material?
- ☐ Are countertops lipped toward the sink?
- ☐ Has a plumbed-in emergency eyewash station and/or shower been provided in laboratories where corrosive chemicals are used? The preferred location of the shower is in an adjacent nook that is equipped with a wastewater holding receptacle (rather than direct drainage into a sewage system).
- ☐ Water taps may be located inside the fume hood cabinet, if there is a main shutoff valve in another area of the laboratory.



Storage and Preparation Facilities

- ☐ Is the chemical storage area adequate in size, well ventilated, secured from student access, built with material having a low flame-spread rating, and does it have adequate drainage at the lowest point?
- ☐ Are adequate areas for the long-term storage of laboratory equipment, supplies and safety equipment provided?
- ☐ Are preparation areas (including bench space, sink and fume hood for making solutions and other materials for class use) provided? These should also allow for storage of SDS, WHMIS and TDG information.
- ☐ Are areas for temporary storage of materials for later use, left-over materials from laboratory activities, and chemical waste storage for year-end disposal provided?
- ☐ Is adequate refrigeration available for storing fresh tissue/organs, enzymes, specific chemicals, agar plates and perishables?

Section 8

Chemicals

NOTE: The information available from various provincial and (WCB) WorkSafeBC sources (NFPA 400 – "Hazardous Materials Code", NFPA 30 – "Flammable and Combustible Liquids", and NFPA 45 – "Fire Protection for Labs using Chemicals", etc.) should be used as the primary sources of information when discussing safe practices within the school science lab area.

The information discussed in this section can be used to enhance the provincial and (WCB) WorkSafeBC sources, if required.

Here is what we will cover in this section of the manual:

- Chemicals in Labs
- WHMIS
- Education and Training
- Chemical Storage
    - Suggested Practices in the Storage and Handling of Laboratory Chemicals
    - General Rules for Chemical Storage
        - Criteria for Storage Area
        - Organization
        - Chemical Segregation
        - Storage Restrictions
        - Proper Use of Chemical Storage Containers
        - A Suggested Model for Chemical Storage
        - Suggested Shelf Storage Patterns (Inorganic, Organic and Other)
- Managing Spills
    - Corrosive Liquids
    - Flammable Liquids
    - Water-Soluble Liquids
    - Water-Insoluble Liquids
    - Solids
- Disposal of Materials, Chemicals and Related Substances – Suggested Methods

Chemicals in Labs

It is very important to always know exactly what chemicals are located in a science lab setting, as well as the recommended practices for use, storage and disposal.

Many incidents have occurred in the past due to non-standard storage and mixing of chemicals, compressed gases, flammable and combustible materials as well as others. The mixing of non-compatible substances can result in fire, leaks, explosions and other potential hazards that can lead to the injury of both students and staff.
When developing a system to determine what chemicals are needed to meet the requirements for a high school science lab, the following procedures should be applied (at a minimum):

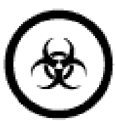
1. Take an inventory;
2. Determine what chemicals you actually use;
3. Organize your chemical storage area;
4. Remove any dangerous chemicals;
5. Continually improve the chemical storage area;
6. Organize chemicals by compatible families; and
7. Develop a chemical disposal program.

WHMIS (Workplace Hazardous Materials Information System)

The purpose of a WHMIS program in all workplaces is to ensure that all people working or being instructed in that area are provided with adequate health and safety information. There are various controlled products discussed in the WHMIS program, but all fall under one or more of the following categories:

1. Compressed gases;
2. Flammable or combustible materials;
3. Oxidizing materials;
4. Poisonous or infectious materials (including biohazardous materials);
5. Corrosive materials; and/or
6. Dangerously reactive materials.

The symbols WHMIS uses to identify hazardous materials are:

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

* The GHS system also defines an Environmental hazards group. This group (and its classes) was not adopted in WHMIS 2015. However, you may see the environmental classes listed on labels and Safety Data Sheets (SDSs). Including information about environmental hazards is allowed by WHMIS 2015.

To help ensure that any persons who work with or around potentially dangerous materials have the required health and safety information provided, WHMIS focuses on the following three elements:

- Proper labels (supplier and workplace labels);
- Safety Data Sheets ("SDS" sheets); and
- Education and training.

LABELS

Suppliers are required to provide labels for the following supplies:

- <u>Laboratory Chemicals</u>: products from a laboratory supply house, packaged in quantities of less than 10 kg and intended for use in laboratories.
- <u>Laboratory Samples</u>: samples of a controlled product that are intended solely to be tested in a laboratory, packaged in quantities of less than 10 kg.
- <u>Workplace chemicals (>100 ml)</u>: products other than laboratory chemicals or samples, packaged in containers of more than 100 ml.

- Workplace chemicals (<100 ml): products other than laboratory chemicals or samples, packaged in containers of less than 100 ml.

Information required on a suppliers label	Lab Chemical	Lab Sample	Workplace chemical > 100ml	Workplace chemical < 100 ml
Product Identification (name)	X	X	X	X
Hazard symbols (classification)			X	X
Risk phrases	X		X	
Precautionary statements	X		X	
First Aid measures	X		X	
Supplier Identification		X	X	X
Reference to availability of SDS	X		X	X
English (and French)	X	X	X	X

Workplace Labels

If a chemical is transferred from its original container and is intended for use in the science lab, the teacher or designated person must ensure the contents are clearly identified on the container.

Workplace labels must include the following:

- The product identification;
- Safe handling information; and
- Reference to a safety data sheet.

Safety Data Sheets (SDS sheets)

A safety data sheet is a technical bulletin provided by a supplier for each controlled product they sell. The SDS sheets contain information in regard to detailed, product specific hazards, precautionary information, and emergency information. Other related topics that relate to the product being used and specific hazard and safety related information that needs to be understood when using that specific material.

SDS sheets need to be available at all times as reference tools for persons working in the environment, occupational health and safety committees, and in some cases, emergency responders.

Education and Training

Training should be provided for all employees that work in a science lab. This would include lab technicians, teachers, support staff, custodians, and other staff who may have to enter these areas to provide repairs and other related services.

The education and training provided must include the following information:

- Elements of WHMIS (Work Hazardous Materials Information System);
- Hazards of the chemicals being used;
- Rights and responsibilities of those persons working in the environment; and
- Information required on labels and SDS sheets, and the significance of that information.

Chemical Storage

Suggested Practices in the Storage and Handling of Laboratory Chemicals

1. Storage of concentrated acids and bases should be limited to a maximum of 2 pints (1 litre) per product, unless you have an area designed and equipped for more volume. You may wish to consider acquiring an acid storage cabinet for this purpose.
2. No flammable materials should be stored outside an approved flammables storage cabinet. Flammables kept outside a cabinet should be in safety cans.
3. Do not allow incoming shipments of chemicals to be opened and transported by school personnel other than qualified science teachers; the special and expensive shipping containers used are frequently discarded and would prove valuable for shelf storage.
4. If possible, keep certain items in the original shipping package (i.e. acids and bases in their special and expensive Styrofoam cubes).
5. All chemicals should be dated upon receipt.
6. A permanent and perpetual inventory should be maintained.
7. Establish a separate, secured storage area for chemicals.
8. All chemicals should be stored in chemically compatible families (see charts below).
9. Avoid storing chemicals on shelves above eye level.
10. The storage area and cabinets should be labeled to identify the hazardous nature of products stored within.
11. Fire extinguishers of the proper type (multi-purpose ABC) and size (minimum 3A10BC), and in good working order, should be placed in the chemical storage area.
12. Shelving above any work area (e.g. sinks), should be free of chemicals and loose items.
13. Shelving sections should be secured to walls or floor to prevent tipping of entire sections.
14. Shelves should be equipped with lips to prevent products from rolling off.
15. Chemicals should not be stored on the floor (except in approved shipping containers).

16. Storage area should be ventilated by at least four changes of air per hour. Isolate the chemical storage exhaust from the building ventilation system.

17. No unlabeled products should be stored anywhere in the science facility.

18. There should be two methods of exiting a chemical storage area. Exits should be entirely free of the presence of hazardous materials.

19. Be thoroughly familiar with the hazards and precautions for protection before using any chemical. Study the precautionary label and review its contents frequently.

20. Know applicable local regulations before disposing of chemicals.

21. Never store chemicals in a standard refrigerator (explosion-proofing is required).

22. Do not store chemicals on or in a fume hood.

23. Open cans of ether should be drained after use and not stored (unless absolutely necessary). Rely on the expiration date to dispose of the material.

24. Glycerin should only be available to the instructor.

25. Water-reactive products (such as sodium or potassium metal, etc.) should be stored as recommended.

26. Neutralizing chemicals (such as a spill kit, dry sand, vermiculite, and other spill control materials) should be readily available.

27. Establish an annual safety review procedure for your chemical storage area.

28. Post emergency telephone numbers in the chemical storage area. Ideally, a telephone should be located in this area also, to be used in the event of an emergency.

29. Smoke / heat detectors should be installed in the chemical storage area.

30. Review the school's purchasing practices. If the science department will be held responsible for safety, then the science department should have a say in how the chemicals are acquired.

31. An approved eyewash station, emergency shower and fire blanket should be within 25 feet of the chemical storage area.

32. Discourage the purchasing of large containers of chemicals to then be dispensed into smaller containers.

33. Keep sources of ignition away from the chemical storage area.

34. Chemicals should not be stored in the science classroom or laboratory; but rather in a separate and securable dedicated area.

General Rules for Chemical Storage

Criteria for Storage Area

- Store chemicals inside a closing cabinet or on a sturdy shelf with a front edge lip (to prevent accidents and chemical spills, a ¾-inch front edge lip is recommended).
- Secure shelving to the wall or floor.
- Ensure that all storage areas have doors with locks.
- Keep chemical storage areas off limits to all students.
- Ventilate storage areas adequately.

Organization

- Organize chemicals by **compatibility first** (see charts below).
- Store alphabetically within compatible groups.

Chemical Segregation

- Store acids in a dedicated acid cabinet. Nitric acid should be stored alone, unless the cabinet provides a separate compartment for nitric acid storage.
- Store highly toxic chemicals in a dedicated, lockable poison cabinet that has been labeled with a highly visible sign.
- Store volatile and odoriferous chemicals in a ventilated cabinet.
- Store flammables in an approved flammable liquid storage cabinet (see charts below).
- Store water-sensitive chemicals in a watertight cabinet, in a cool and dry location which is segregated from all other chemicals in the laboratory.

Storage Restrictions

- Do not place heavy materials, liquid chemicals, or large containers on high shelves.
- Do not store chemicals on the tops of cabinets.
- Do not store chemicals on the floor (even temporarily).
- Do not store items on benchtops and in laboratory chemical hoods, except when in use.
- Do not store chemicals on shelves above eye level.
- Do not store chemicals with food and drink.
- Do not store chemicals in personal staff refrigerators (even temporarily).
- Do not expose stored chemicals to direct heat or sunlight, or highly variable temperatures.

Proper Use of Chemical Storage Containers

- Never use food containers for chemical storage.
- Make sure all containers are properly closed.
- After each use, carefully wipe down the outside of any containers with paper towel before returning them to the storage area; be sure to properly dispose of the paper towel afterward.

A Suggested Model for Chemical Storage

This represents an effective, yet economically feasible model, which can be adapted to any school chemical storage situation.

The characteristics of an effective chemical storage facility include:

- Locking doors that isolate the chemical storage area from preparation areas and classrooms;
- Using a WHMIS approved labelling system that segregates all chemicals into classes (to make it easy to access and replace them in their proper storage position); and
- Using an effective ventilation system.

A chemical storage room must be secured to prevent theft and unwarranted use of chemical stock. A different key from those used to enter classrooms or the preparation areas is essential, so as to allow only authorized personnel to access the chemical storage room.

The chemical storage room must be adequately vented (as per standards and codes), with a fan that runs continuously. Installation of explosion-proof lights, switches, and fan motor housing, helps to prevent fires due to electrical shorts, or sparks in faulty switches. Ground fault interrupter (GFI) circuits should also be installed, especially near sinks. Ceilings and walls should be constructed with gypsum board, or some similar non-combustible material.

The chemical storage area must house all of the chemical stock used in the science program. A large high school (800-1000 students) may require a room with approximately 150 m of shelf space. Smaller schools (offering only middle school science) may require 80 m of shelf space. Combined middle and high schools may require 200 m of shelf space.

Problems often arise because of the quantities of chemical stock ordered from year to year. If the school is unable to accommodate its chemical stores in a facility similar to the one described in this section, schools should closely examine the amount of material they have in storage. As a general rule, do not order more chemical stock than the school plans to use annually.

Suggested Shelf Storage Pattern

A suggested arrangement of compatible chemical families on shelves in a chemical storage room is depicted below. However, this list of chemicals does not mean that all these chemicals should be used in high school science labs.

- First sort chemicals into organic and inorganic classes.
- Next, separate into the following listed compatible families:

	Inorganics		Organics
1	Metals, Hydrides	1	Acids, Anhydrides, Peracids
2	Halides, Halogens, Phosphates, Sulfates, Sulfites, Thiosulfates	2	Alcohols, Amides, Amines, Glycols, Imides, Imines
3	Amides, Azides, Nitrates (except Ammonium Nitrate), Nitrites, Nitric Acid	3	Aldehydes, Esters, Hydrocarbons
4	Carbon, Carbonates, Hydroxides, Oxides, Silicates	4	Ethers, Ethylene Oxide, Halogenated Hydrocarbons, Ketenes, Ketones
5	Carbides, Nitrides, Phosphides, Selenides, Sulfides	5	Epoxy Compounds, Isocyanates
6	Chlorates, Chlorites, Hydrogen Peroxide, Hypochlorites, Perchlorates, Perchloric Acid, Peroxides	6	Azides, Hydroperoxides, Peroxides
7	Arsenates, Cyanates, Cyanides	7	Nitriles, Polysulfides, Sulfides, Sulfoxides
8	Borates, Chromates, Manganates, Permanganates	8	Cresols, Phenols
9	Acids (except Nitric Acid)		
10	Arsenic, Phosphorous, Phosphorous Pentoxide, Sulfur		

Suggested Shelf Storage Pattern for Inorganics

ACID STORAGE CABINET ACID INORGANIC #9 Acids, EXCEPT Nitric Acid - Store Nitric Acid away from other acids unless the cabinet provides a separate compartment for Nitric Acid storage.

DO NOT STORE CHEMICALS ON THE FLOOR

Inorganic #10 Arsenic, Phosphorous, Phosphorous Pentoxide, Sulfur	**Inorganic #7** Arsenates, Cyanates, Cyanides - **STORE AWAY FROM WATER**
Inorganic #2 Halides, Halogens, Phosphates, Sulfates, Sulfites, Thiosulfates	**Inorganic #5** Carbides, nitrides, Phosphides, Selenides, Sulfides
Inorganic #3 Amides, Azides, nitrates, Nitrites **- EXCEPT Ammonium Nitrate - STORE AMMONIUM NITRATE AWAY FROM ALL OTHER SUBSTANCES**	**Inorganic #8** Borates, Chromates, Manganates, Permanganates
Inorganic #1 Hydrides, Metals **- STORE AWAY FROM WATER. STORE ANY FLAMMABLE SOLIDS IN DEDICATED CABINET**	**Inorganic #6** Chlorates, Chlorites, Hypochlorites, Hydrogen Peroxide, Perchlorates, Perchloric Acid, Peroxides
Inorganic #4 Carbon, Carbonates, Hydroxides, Oxides, Silicates	**Miscellaneous**

Suggested Shelf Storage Pattern for Organics

Organic #2 Alchohols, Amides, Amines, Imides, Imines, Glycols **- STORE FLAMMABLES IN A DEDICATED CABINET**	**Organic #8** Cresols, Phenol
Organic #3 Aldehydes, Esters, Hydrocarbons **- STORE FLAMMABLES IN A DEDICATED CABINET**	**Organic #6** Azides, Hydroperoxides, Peroxides
Organic #4 Ethers, Ethylene Oxide, Halogenated Hydrocarbons, Ketenes, Ketones **- STORE FLAMMABLES IN A DEDICATED CABINET**	**Organic #1** Acids, Anydrides, Peracids **- STORE CERTAIN ORGANIC ACIDS IN ACID CABINET**
Organic #5 Epoxy Compounds, Isocyanates	**Miscellaneous**
Organic #7 Nitriles, Polysulfides, Sulfides, Sulfoxides, etc.	**Miscellaneous**

POISON STORAGE CABINET - Toxic substances

FLAMMABLE STORAGE CABINET - FLAMMABLE ORGANIC #2 - Alcohols, Glycols, etc.

FLAMMABLE ORGANIC #3 - Hydrocarbons, Esters, etc.

FLAMMABLE ORGANIC #4

DO NOT STORE CHEMICALS ON THE FLOOR

Other Storage Suggestions

- Avoid floor chemical storage (even temporarily);
- Avoid chemical storage on top of shelving units;
- Avoid chemicals stored above eye level;
- Fasten shelf assemblies securely to a wall (avoid island shelf assemblies);
- Make shelving assemblies out of wood;
- Provide lips on all shelves to prevent roll-off;
- Avoid metal, adjustable shelf supports or clips (fixed, wooden supports are preferred);
- Store both inorganic and organic **acids** in a dedicated acid cabinet with doors;
- Store **nitric acid** in a location isolated from other chemicals;
- Store flammables in a dedicated metal cabinet with doors; and
- Store extremely toxic poisons in a locked cabinet.

Managing Spills

Deciding how to handle a spill first requires an understanding of the health hazards associated with the substance. There are three immediate questions that must be answered:

- Is this substance highly toxic or corrosive?
- Does it give off toxic or corrosive fumes?
- Are the fumes potentially explosive?

Answers to these questions can be found in the pertinent SDS sheets that should be accessible to users at all times, and which should be reviewed before commencing activities with the materials. For substances that are highly toxic or corrosive (ones that have a health rating of 3 or 4), any spills and/or release of these substances must be handled by specially trained professionals who are equipped to deal with such emergencies. This may require evacuation of the school; particularly if toxic fumes are associated with the substance.

If any spills of acids and/or bases should occur, action can be taken by knowledgeable staff to neutralize the spill using materials provided for that purpose. Once neutralized, the products can then be cleaned up and disposed of.

Prompt cleanup is appropriate to deal with manageable quantities of other materials that are not highly toxic or corrosive. All waste resulting from these cleanups should be contained separately. Placing all spilled or waste chemicals in a general bin may result in reactions between chemicals or waste placed in the container.

Corrosive Liquids

Minor spills of corrosive liquids can be handled as follows:

1. Put on protective clothing/equipment (face shield, rubber gloves, rubber boots and lab coat) if the spill is concentrated;
2. Contain the spill with asbestos-free vermiculite, clay cat litter (bentonite) or diatomaceous earth;
3. Neutralize the substance. For acids, liberally apply sodium bicarbonate (baking soda) or sodium carbonate (soda ash), or a spill kit pillow. For bases, apply boric or citric acid on the spill, or a spill kit pillow. Test with pH paper to ensure the substance has been completely neutralized;
4. Dilute with plenty of water and mop up using an absorbent cloth; and
5. Wash remaining contents down the sink and clean the spill area with water, wiping the area dry afterward with paper towel.

NOTE: Municipal bylaws and waste regulations may permit some substances to be disposed of through drains. If permitted in your area, wash the material down with plenty of water. Alternatively, absorbent materials (asbestos-free vermiculite or diatomaceous earth) may be used to soak up the solution. The resulting mixture can then be bagged, labelled and disposed of.

Flammable Liquids

Small amounts of solvents can be cleaned up as follows:

1. Immediately shut off all ignition sources, and open windows and vents leading directly to the outside for ventilation.
2. Contain and cover the spill with a mineral absorbent such as asbestos-free vermiculite, bentonite or diatomaceous earth.
3. Scoop contaminated absorbent into a heavy gauge garbage bag or plastic lidded bucket.
4. Wash the spill area with soap and water, using a disposable cloth.
5. Dispose of the contaminated cloth in the same garbage bag or bucket.
6. Allow to evaporate under the fume hood.

Water-Soluble Liquids

1. If needed, contain with towels, asbestos-free vermiculite, bentonite or diatomaceous earth.
2. Dilute with water.
3. Mop up using paper towel or cloths. Very small spills can be swabbed directly into a sink and flushed with large volumes of water.
4. Check the chemical hazard information located on the SDS sheets for disposal details.

Water-Insoluble Liquids

1. If needed, contain with towels, asbestos-free vermiculite, bentonite or diatomaceous earth.
2. Cover the spill with mineral absorbent and scoop the contaminated material into a suitable container for disposal.
3. Wash the spill area with water and soap and wipe dry with paper towel.
4. Discard contaminated towel or cloth and check the SDS sheets for disposal details.

Solids

The critical factor in cleaning up solid chemicals is to avoid raising particles into the air and inhaling them:

1. Slowly sweep up granules or powder into a dustpan.
2. Mop up smaller amounts with a damp, disposable cloth.
3. Wipe the area clean.
4. Check the information located on the SDS sheets for final disposal details.

Disposal of Materials, Chemicals and Related Substances – Suggested Methods
(See Appendix "E")

Disposal of Biological Materials

The greatest hazards in the biology classroom come from dissected organisms and microbiological specimens. Ideally, much of this material should be incinerated. If this is impossible, place carcasses and animal remains in heavy, opaque, well-sealed biohazard plastic bags, and send them to the local landfill.

Burying the remains near the school may result in wild animals and pets digging them up. Autoclave used petri dishes and cultures in autoclavable disposable bags. Autoclave liquid cultures and pour them down a drain with large amounts of water. Dispose of syringes, needles, scalpels, and razor blades in a labelled metal or thick plastic container.

Disposal of Chemicals

NOTE: The following information discusses **suggested methods of chemical disposal only**. Before a system is put into place, local, provincial and federal guidelines and regulations should always be reviewed and adhered to.

The four methods of dealing with chemical wastes include:

- Flushing into drains;
- Landfilling;
- Incinerating; and
- Reclaiming.

Disposal of chemicals on your own can be costly; useful references for disposal yourself are:

- National Research Council – Prudent Practices in the Laboratory: Handling and Management of Chemical Hazards; and
- Flinn – Chemistry Catalogue Reference Manual.

Small Chemical Spills

Weak acids and bases can be flushed down sinks with large quantities of water. Small amounts of solvents can be evaporated in a fume hood. Small spills of poisonous or highly reactive materials must be dealt with responsibly (e.g. mercury is highly toxic even in small amounts. A broken thermometer should be cleaned up immediately using a mercury spill kit, be packaged and sent to or picked up by a designated hazardous materials company).

Large Chemical Spills

Concentrated acid and base spills require protective clothing/equipment during cleanup and disposal. Face shields, rubber gloves, rubber boots, and lab coats should be worn. Large spill kit pillows can be used to absorb and neutralize these spills. If spill kits are not available, then acids must be neutralized with dry sodium bicarbonate and bases with diluted hydrochloric or acetic acid.

Neutralized spills must be further diluted with plenty of water. If a floor drain exists, it is usually permissible to wash the mixture down the drain with plenty of water (provided it is not prohibited by municipal bylaws or special regulations). Alternatively, absorbent materials (vermiculite or diatomaceous earth) may be used to soak up the solution. The resulting mixture is then bagged, labelled, and sent to or picked up by a licensed hazardous waste management company.

Spill Kits

The items listed below will enable you to deal with most common spills of acids, alkaline solutions, flammable solvents, and mercury. **Commercial spill kits (available from most scientific supply companies) are the most convenient to use and are recommended.**

- Vermiculite (6 kg) and activated charcoal (1 kg) mixture;
- Bentonite or cat litter (10 kg);
- Sodium bicarbonate (3-4 kg of dry solid);
- Weak acid (liquid or solid);
- Various size freezer bags with ties;
- Dustpan;
- Whisk broom;
- Labels and tape; and
- Metal containers for flammable wastes.

Disposal through an Organization (Hazardous Waste Management Company)

Before removing unwanted chemicals, examine and follow the chemical disposal policy of the school or division. Prepare materials for delivery or pick up by:

- Placing each chemical container in a heavy, clear plastic bag (freezer bags work well);
- Seal the bag and label the contents;
- Pack the bag in a box using vermiculite, Styrofoam chips, or a similar packing material;
- Label, then seal the box with tape;
- Keep acids and reduce agents separately (if the quantity of disposables is large, pack chemicals from different hazard groupings in separate boxes);
- Deliver to or have all materials picked up by the waste management company; and
- Avoid packing explosive or highly reactive substances.

Teaching about Spill Cleanup

It is important that students have practical experience in spill cleanup and disposal procedures. A sample lesson plan is provided below, but teachers are encouraged to discuss and demonstrate spill cleanup procedures in the context of all laboratory activities.

Sample Lesson Plan

Timeline: Two or three fifteen-minute lessons

Placement: During any chemistry unit in middle or senior years

- Discussion: when distributing mercury thermometers, outline the proper procedure if one should break and discuss the hazards associated with mercury vapour.
- Demonstration: simulate a spill of sulphuric acid from a beaker. Indicate the need to keep the bench area clean and clear of books, papers, and purses. Show students the proper cleanup procedure and insist on the importance of telling the teacher immediately about any accidents, spills, or contact of chemicals with skin or clothing.
- Demonstration: show students how to clean up an ethanol spill.
- Practice: simulate spills (with water) to have students practice cleanup procedures. You may designate some spills as specific substances, or tell the students to clean the spill as if it were an unknown liquid. Be sure to include questions regarding these procedures on safety quizzes or exams.

For more information on suggested methods of chemical disposal, see **Appendix "E"** at the end of this manual.

Section 9

Hazards

NOTE: The information available from various provincial and (WCB) WorkSafeBC sources should be used as the primary sources of information when discussing safe practices within the school science lab area.

The information discussed in this section can be used to enhance the provincial and (WCB) WorkSafeBC sources, if required.

The following information will be discussed in this section of the manual:

- Minimizing Risks of Chemical Exposures
- Corrosive Substances
- Explosive Substances & Reactive Chemicals
- Insidious Hazards
- Toxic Hazards
- Mercury
- Biological Hazards
- Radiation Hazards
- Carcinogens Hazards
- Cryogenic Substances
- Mechanical and Electrical Hazards
- Fires
- Flammable & Combustible Liquids
- Compressed Gases
- Heat Producing Devices

Minimizing Risks of Chemical Exposure

Whenever chemicals are used, the onus is on the teacher to assess risks, determine proper handling procedures and convey this information to students before beginning the activity. Handling procedures used for all chemicals, and especially those with greater hazards, should aim to minimize exposure. This can be accomplished through strategies such as the following:

- Do not handle hazardous materials in open containers, as vapours, dust and liquids can easily escape during normal handling.
- Do not heat hazardous materials, as smoke and vapour may be released in much greater quantity when material is hot.

- Avoid crushing/grinding solids or unnecessarily transferring powders, as this creates dust.
- Use and store hazardous materials only in areas with adequate ventilation. Toxic vapours can rapidly accumulate to dangerous levels in a room (or part of a room) that do not have a constant replacement of fresh air.
- Do not lean over open bottles, as toxic vapours can be concentrated directly above the bottle even in well-ventilated rooms.
- Ensure chemicals are clearly labeled and check these labels every time a substance is used. Odour and appearance are not reliable guides to the toxicity of substances: dangerous liquids can be clear and odourless, and toxic vapours may have little or no odour (even at dangerous concentration levels).
- Use proper protective gear such as correct clothing, face protection, fume hoods or respirators to prevent skin contact with hazardous materials and inhalation of toxic vapours.
- Do not chew gum, smoke, store or consume food or beverages, in an area where hazardous materials are used. Food, beverages and cigarettes can easily absorb hazardous vapours or be contaminated with unseen toxic dust. Poisons may also be transferred from hands to food or cigarettes.
- Follow proper cleanup procedures after each lab activity is finished. Substances left on benches or in beakers and bottles may expose others to these toxic materials.
- Ensure students wash their hands thoroughly after activities to avoid transferring toxic materials to food they eat.

Insidious hazards could be easily overlooked or ignored (even during routine safety inspections), because they do not have immediately obvious effects. To avoid or reduce these kinds of hazards, consider the following measures.

- Give specific attention to possible sources of hazards during the safety inspection process.
- Prepare an inventory of hazards that must be tended to regularly.
- Provide adequate ventilation in the form of hoods and forced air, as stated in current standards and codes.
- Avoid stock buildup of toxic, flammable or corrosive materials.
- Keep appropriate cleanup agents accessible in case of spills.
- Collect waste materials in separate containers and do not mix.
- Perform diligent and regular housekeeping.

Corrosive Substances

Corrosive chemicals cause visible, usually rapid damage to human tissue at the site of contact. Often this corrosive quality is due to the reaction of the substance with water or moisture in the tissue (this is the case with strong acids and bases of 1 M or greater concentration, non-metal halides, dehydrating agents, halogens and oxidizing agents). The most serious corrosive hazards come with substances that are in a mist or gaseous state, since they can be readily absorbed through the skin or inhaled into the lungs.

The corrosive properties of chemicals commonly found in schools are identified and discussed in the SDS sheets and other related documentation.

Explosive Substances and Reactive Chemicals

Concentrated forms of unstable substances that have the potential to explode pose too great a risk to warrant use in schools and should not be kept. Some explosive substances in lower concentrations (e.g. hydrogen peroxide) are relatively safe. For more information on explosive substances and reactive chemicals, refer to the SDS sheets and other related documentation.

Insidious Hazards

The most obvious source of insidious chemical hazards is from substances known to have dangerous long-term effects, such as mercury and carcinogens, which are discussed further below. These substances can cause damage through direct exposure or through leakage of vapours or fumes from chemical containers. However, even if such chemicals are not intentionally ordered and stored in the schools, insidious hazards can still exist and be easily overlooked.

These hazards include:

- Leaking gas cylinders;
- Formaldehyde from biological specimens;
- Mixed chemicals that slowly react to form toxic products, particularly mixtures of waste;
- Neglected containers of dried solutions and residue of chemical products from past demonstrations and activities; and
- Residue from chemicals improperly disposed of in the sink drain, resulting in subsequent interactions that cause the formation and release of toxic or other hazardous materials into the laboratory air.

Toxic Hazards

Toxic or corrosive properties are the most common hazards posed by chemicals in schools. A toxic substance is any substance that may cause damage by its chemical action when ingested, inhaled, absorbed or injected into the body in relatively small amounts. Damage can occur when materials:

- Directly destroy tissue through corrosive action (e.g. NaOH reacts with skin moisture);
- Interfere with chemical reactions of the body (e.g. CO replaces O2 in hemoglobin); and
- Disrupt the biological processes of the body (e.g. NO2 causes pulmonary edema and allergic responses).

Exposure to Toxic Materials

Toxic materials can enter the body by:

- Inhalation: breathing in poisonous or corrosive vapours and dust (the most common route by which toxic materials enter the body);
- Ingestion: swallowing liquid or solid toxic materials;
- Direct entry: chemicals entering through open wounds or directly injected through punctures, allowing chemicals access to the bloodstream; and
- Contact: absorbing toxic materials through skin, mucous membrane or eyes.

Since inhalation of vapours or dust is the most common way that toxic materials enter the body, every effort should be made to avoid circumstances that allow this to happen. Any activities that involve use of toxic materials in liquid, vapour or dust form should only be carried out under a fume hood.

Effects of Toxic Chemicals

Toxic effects can be local or systemic, acute or chronic. Local effects are confined to the area of the body that has come in contact with toxic materials; systemic effects occur throughout the body after absorption into the bloodstream; and acute effects are immediate and usually extremely serious or painful. With chemicals that can produce acute effects, poisoning may be suspected when any of the following are evident:

- Strange odour on the breath;
- Discolouration of lips and mouth;
- Pain or burning sensation in the throat; and/or
- Unconsciousness, confusion or sudden illness.

By comparison, chronic effects are long lasting and may take many years before becoming evident. Many substances (such as arsenic and mercury) have cumulative effects, meaning that poisoning may occur at lower concentrations through repeated exposures over a period of time. Such substances are sometimes known as “insidious” hazards.

Insidious substances include carcinogens, teratogens and mutagens.

Carcinogens cause cancer in cells. Teratogens interrupt or alter the normal development of a fetus. These include chemicals such as ethanol and mercury compounds, viruses such as rubella, and ionizing radiation. Mutagens increase the rate of mutation of cells or organisms, and include chemicals such as nitrous acid, peroxides and dichromates, as well as certain viruses and radiation.

Mercury

One relatively well-known hazardous substance is mercury, which can have serious and cumulative effects on the gastrointestinal and central nervous systems. Open mercury evaporates and readily absorbs through the skin and respiratory system. Disposal of mercury and mercury compounds is an ongoing major concern.

Given the hazards of mercury, it is not recommended for use in schools. Mercury thermometers should no longer be used in schools because of the potential for breakages and spills. If mercury is still in stock, the following steps need to be taken to manage it more safely:

- Store mercury in plastic bottles under a layer of water or oil;
- Keep the container sealed in a cool, well-ventilated area;
- Avoid opening the container and allowing vapours to escape; and
- Wear gloves when handling containers.

Mercury spills from thermometers, thermostats or any other source must be cleaned up immediately and thoroughly, regardless of the size of the spill. Unless spills are promptly and thoroughly cleaned up and the area decontaminated, dangerous exposure to vapours will continue. In the past, the common practice for cleaning was to aspirate or sweep up any visible drops. Often, small droplets hidden in cracks and crevices were inadvertently left behind to evaporate into the atmosphere.

Mercury droplets from 10 to 1000 micrometres in diameter also stick to vertical surfaces and penetrate into porous flooring. In some cases, relatively large amounts of mercury may be left undiscovered after spills. Prompt and thorough cleanup of mercury spills is essential; cumulative exposure to mercury vapours can cause irreparable harm to those working in the area.

The cleanup procedures for mercury spills in schools are determined by local school boards, provincial and federal regulations and other related regulations and standards. Some boards may permit school staff to clean spills using commercial spill kits; while others specifically restrict cleanup to professionals (i.e. hazmat cleanup specialists). Check your school board's policy on mercury spills before proceeding with the actual process. If board policy allows staff to perform cleanup, use a commercial spill kit that includes components to control vapours (i.e. aspirator, mercury absorbent and vapour absorbent).

Biological Hazards

Micro organisms, like toxic chemicals, are a potential hazard for persons performing biological experiments. Working with them requires special handling, storage and disposal techniques. Teachers or instructors must be fully aware of the hazards that may be presented by infectious agents and their possible sources.

Common causes of accidental infection:

- Oral aspiration through pipettes;
- Accidental syringe inoculation;
- Animal bites, scratches, or simple contact with an animal;
- Spray from syringes;
- Centrifuge accidents;
- Allergic reaction to plants;
- Cuts or scratches from contaminated glassware;
- Cuts from dissecting instruments;
- The spilling or dropping of cultures; and
- Airborne contaminants entering the body through the respiratory tract.

NOTE: Due to potential for serious injury when performing experiments or dissections with biological specimens, extreme caution should be provided.

Radiation Hazards

Radiation is everywhere in this day and age. Today, with more electronic equipment and a greater variety of experimental procedures (including nuclear experiments), an increase in radiation sources in the school laboratory has resulted. The effects of radiation are well known and well documented. Any equipment or chemical substances that may give off radiation should carry the required warning labels and all precautionary measures should be followed.

The governing of equipment and substances that give off radiation typically falls under local, provincial and federal regulations and guidelines. Full planning, including emergency procedures, protective equipment and accidental release procedures, should be fully documented and in place before the first use of the materials.

Carcinogens Hazards

A carcinogen is a chemical, physical or biological substance that is capable of causing cancer. The damaging effects are subtle and imperceptible in the short term, thus carcinogenic substances are another insidious hazard that may be present in the laboratory and chemical storage area. A substance is considered to be carcinogenic if it has been evaluated and rated as a human carcinogen, an animal carcinogen or a potential carcinogen by the American Conference of Governmental Industrial Hygienists (ACGIH) or the International Agency for Research on Cancer (IARC). These substances are categorized under WHMIS as Class D2.

The Canadian Cancer Society has more information available on its website with respect to the classification and identification of carcinogenic substances, located at: http://www.cancer.ca/en/prevention-and-screening/be-aware/harmful-substances-and-environmental-risks/classifying-carcinogens/region.

Actual manifestation of cancer or tumors for most carcinogenic chemicals requires prolonged and often relatively constant exposure. Proper storage of such chemicals in airtight containers reduces this hazard by limiting exposure only to periods of chemical usage. However, the more frequent the use, the greater the exposure (particularly for powdered forms of these chemicals, which can be absorbed through the skin and lungs).

Fewer chemicals have carcinogenic properties compared to other risks, and those that do should be avoided, if possible. Whether to stock and use chemicals with carcinogenic properties will depend on curricular requirements, adequacy of facilities and the ability to safely handle these chemicals with the frequency required. Serious consideration should be given to using alternative chemicals wherever possible.

Cryogenic Substances (liquefied/solidified gases)

Cryogenic substances are gases that are maintained in liquid or solid form at extremely low temperatures. The most common cryogens that are readily available to schools are solid carbon dioxide (dry ice) and liquid forms of hydrogen, oxygen, methane and nitrogen.

Cryogens pose several serious hazards. These include:

- Explosive Pressure: cryogenic gas generates enormous pressure when it vaporizes within the container and when released through the valve. In the case of methane gas, for example, the expansion is 630 times that of the equivalent liquid volume.
- Fire: flammable cryogenic substances present the same flammability hazard as their gaseous forms.
- Embrittlement of structural materials and human tissues: most materials experience some degree of embrittlement at temperatures below –50˚ C. Contact with cryogenic liquids, their gases or the surfaces of their containers, can lead to frostbite or to more extensive freezing of tissue that can be very destructive. Living tissue can become completely frozen and so brittle that it will shatter on impact.

- Asphyxiation: except for liquid oxygen, expansion of cryogens may displace a sufficient volume of air to cause asphyxiation. This is particularly true of dry ice, which sublimes into carbon dioxide gas and readily displaces normal air, since it is heavier than other atmospheric gases.

The use of cryogenic compounds is not required to meet any specific learning outcomes in most high schools. Instead, teachers sometimes use these substances to create special effects. Use of cryogens may require submission of a written "Safe Work Procedure" proposal to the local (WCB) WorkSafe Organization or an equivalent department. Before proceeding with ordering and using these substances, check the regulation requirements with your local board office, provincial regulations and others as required.

Only personnel with the necessary expertise and appropriate administrative approval should handle compressed gases or cryogenic substances, including dry ice. Use by students is not recommended. Anyone choosing to use cryogens should have a thorough knowledge of the characteristics of the substance at the temperatures and pressures being used, and the appropriate safety precautions for handling. They should also know how to recognize and eliminate leaks, and the requirements for short and long-term storage. To minimize risks, it is important to take every possible precaution, including the following:

- Use cryogens only in a properly ventilated space to avoid a buildup of gas that may cause fire, explosion or asphyxiation. Adequate ventilation is particularly important to prevent asphyxiation with the use of dry ice.
- Store containers of cryogenics in a cool, well ventilated space, in an upright secured position, and vent containers properly to avoid explosion. Prolonged storage in a poorly ventilated area will cause metal valves to undergo chemical corrosion. If this occurs, store in a separate cool, dry room, away from direct sunlight and sources of sparks or flame.
- Ensure warning signs and the name of the cryogen is all posted in locations where the substance is stored or used.
- Ensure vessels are appropriately labelled and filled only with the liquids that they were designed to hold.
- Perform operations slowly to minimize boiling and splashing.
- If liquid nitrogen is heavily contaminated with oxygen, handle it with precautions suitable for liquid oxygen. The appearance of a blue tint in liquid nitrogen is a direct indication of oxygen contamination.
- Take appropriate precautions when releasing cryogenic gases. If oxygen is used, remember that it does not burn but it does enhance burning of flammable materials; thus open flames or sources of sparks should be removed from the area.
- Ensure that all eyes are protected and all skin is covered by wearing goggles, a face shield, pants and boots, a laboratory coat or apron without pockets or cuffs, and loose-fitting gloves that can be easily removed.
- Remove watches, rings, bracelets and other jewellery.

Mechanical and Electrical Hazards

Mechanical and electrical hazards will seldom exist in a well maintained laboratory where commercially produced, approved equipment is in good working order. With all protective devices and guards in place, there is little opportunity for an accident to occur.

Mechanical Hazards

- All rotating machinery: when guards, lids and covers are not in place over exposed shafts or belts and pulleys, loose clothing, hands and long hair can quickly get caught.
- Use of tools (including glass cutting operations): carelessly used tools, and tools in poor condition, are the source of many accidents resulting in crushed or cut fingers and hands, eye injuries, lesions and abrasions.
- Heavy equipment and materials stored overhead: an accident can cause "mechanical injuries" (injuries resulting from excessive forces being applied to the body) if a heavy overhead item slips while being moved.

Electrical Hazards

- Faulty equipment: poor or broken connections (e.g. frayed connecting cords) may lead to overheating of the input lead or the device itself, or shorting of the circuit to some part of the equipment touched by people (e.g. the metal case). Damage to the equipment, or a fire or electric shock may result.
- Improperly used equipment: equipment damage and overheating, and therefore fire, are possible if equipment is in prolonged use at power ratings greater than that for which the item was designed.
- Installations and modifications that do not meet building code standards: building code specifications are intended to provide safe access to electrical power. If changes or additions are needed in the existing system, they must be made by an electrician. Improper alterations can present a fire or electrical shock hazard if excessive current can flow in the new circuits, or if connections are not properly made and insulated.
- Electrical equipment used near water: if equipment is not properly insulated and grounded and is used near water (e.g. near laboratory sinks), there is a danger of electric shock.
- High voltage equipment (including Tesla coils and charged capacitors): student wired laboratory setups and teacher-made demonstration equipment frequently have exposed connections that present a very real danger of electrical shock when high voltages are being used (e.g. the connection of a high voltage source to a gas discharge tube).

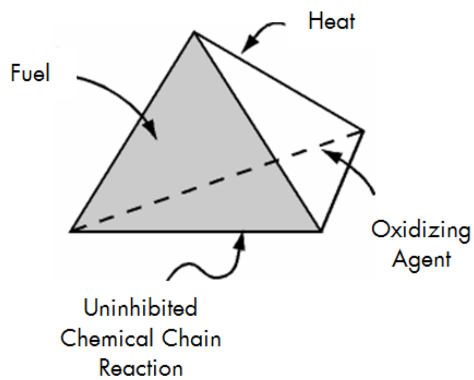
Mechanical and Electrical Hazards Protection Policy

Accident prevention will depend on the proper maintenance of all mechanical and electrical equipment and the careful instruction of students in the safe use of the equipment. The **onus is on the teacher** to be aware of potential dangers and to convey this information to students.
Teachers / Lab technicians must:

- Maintain all equipment and tools in good working order;
- Instruct students in the safe use of all equipment and tools;
- Be sure that all rotating equipment (i.e. centrifuges, vacuum pumps, rock saws, grinders and demonstration motors, etc.) are operated with all covers, lids and guards in place;
- Require that eye protection be used during any grinding or pounding operations;
- Require that students using rotating equipment tie up loose clothing and long hair;
- Clearly Indicate a **"No Crowding Zone"** around all major equipment which requires only one equipment operator;
- Clearly tag all faulty equipment so it will not be used before it is repaired;
- Arrange for any modifications to building installations to be made by district electricians;
- Use electrical equipment at its rated capacity only;
- Be sure all equipment is shut off when not in use;
- Ensure regular safety inspections and completion of dated, signed inspection sheets; and
- Store all heavy items as close to the floor as possible.

Fires

Burning is the rapid oxidation of a fuel by an oxidizer (i.e. air) with the liberation of heat and usually light. A fire can be started when sufficient energy is present to initiate the reaction. The process of burning involves four interrelated components: fuel, oxidizer, an energy source and an uninhibited chemical chain reaction; these components make up the fire tetrahedron. Removal of at least one side is the basis of fire control and safety.



Sources of Fire

Fire has always been one of the attendant hazards of laboratory operation. Laboratories make use of flammable materials including solids, liquids and gases. The following are among the more common sources of fire hazards encountered in school laboratories:

- Ignition of solvent vapours;
- Ignition by reactive chemicals;
- Uncontrolled chemical reactions;
- Inadequate storage and disposal techniques;
- Heating due to electrical faults;
- Loose clothing and hair ignited by the Bunsen burner;
- Misuse of gas cylinders;
- Inadequate maintenance;
- Static electrical buildup;
- Inadequate laboratory design; and
- Inadequate temperature control, especially in areas where solvents are stored.

Fire Safety

The goal of every science teacher should be to reduce the chance of fire to the lowest possible probability. Elements of a successful fire control program include:

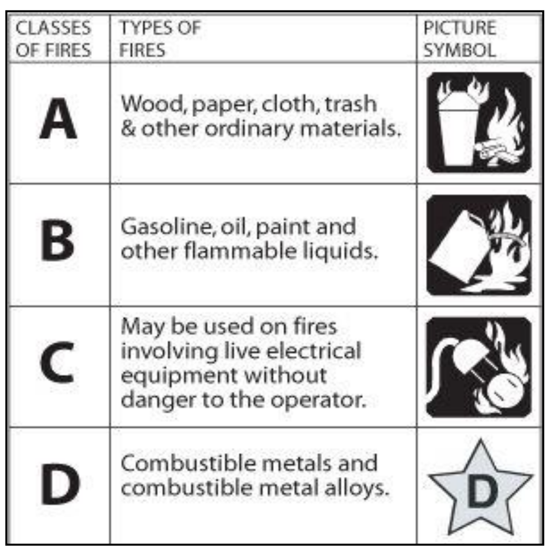
- Adequate education of students in the hazards of fire;
- Use of proper lab procedures;
- Maintenance of proper chemical storage facilities; and
- Provision and maintenance of effective fire control equipment.

Fire Safety Equipment

- Fire blankets: are made of fire-proofed wool / rayon material, and are not to be used where spillage and fire spreading is possible.
- Sand buckets and scoops: are useful for small fires of all kinds.
- Fire extinguishers: the type of fire and extinguisher used are related. Teachers should learn the different classes of fire and the proper extinguisher to use. An extinguisher may act on any of the four sides of the fire tetrahedron, or any combination of them, to extinguish the fire. Usually, however, an extinguisher either cools the area so a fire will not burn (remove energy source), smothers the fire (removes oxidizer), or both.

Fires and Fire Extinguishers

Fire Classification	Fire Extinguisher
Class A: fires involving ordinary combustible materials such as wood, cloth, paper.	Water. Dry chemical extinguisher can be used.
Class B: fires involving flammable liquids such as dry chemical foam.	CO2, Multi–Purpose Class (ABC) extinguishers can be used.
Class C: fires involving electrical equipment.	Non-conducting agents such as dry chemical or carbon dioxide. Multi–Purpose Class (ABC) extinguishers can be used.
Class D: fires involving combustible metals such as magnesium, sodium, lithium, or powdered zinc.	Special dry powder, medium or dry sand.



CLASSES OF FIRES	TYPES OF FIRES	PICTURE SYMBOL
A	Wood, paper, cloth, trash & other ordinary materials.	
B	Gasoline, oil, paint and other flammable liquids.	
C	May be used on fires involving live electrical equipment without danger to the operator.	
D	Combustible metals and combustible metal alloys.	D

Basic requirements as to the location and condition of fire extinguishers:

- Maintain in operable condition and have a **complete** check at least annually;
- Never reuse a used extinguisher; have it recharged;

- Have all extinguishers clearly marked as to class and use;
- Locate conspicuously (i.e. have location marked with signs; preferably near an exit door);
- Mount at an accessible height;
- Locate in an area convenient to area of use; and
- Inspect monthly.

Some Restrictions

- Do not throw water over a chemical fire;
- Do not use a fire extinguisher on standing beakers and flasks; and
- Do not turn on water after a flaming container is placed in a sink.

Flammable and Combustible Liquids and Substances

Generally, substances that are highly flammable (particularly those that are also highly volatile) should not be used by students. If minute amounts are provided for student use, make sure the area is well-ventilated and far from open flames or sparks. Identify and eliminate any unwanted ignition sources that may exist (such as sparks that come with unplugging electrical cords and static electricity). Teacher demonstrations using flammable substances can be done under similar conditions, or under the fume hood.

Again, cabinets and containers used to store flammable liquids, combustible liquids and substances should meet the National Fire Protection Association (NFPA) standard, which is relevant in both Canada and the United States.

Flammable and Combustible Liquid Storage

- The information in regard to minimum recommended practices for storage of flammable and combustible liquids is taken from several standards and regulations, including the BC Fire Code, NFPA 30 (storage of flammable and combustible liquids) and NFPA 45 (fire protection for labs using chemicals).
- These codes and standards dictate the minimum precautions to take for storage, handling, transportation, ventilation and general housekeeping.
- All flammable liquids should be stored in a ULC listed cabinet or ULC listed container.
- Standard ventilation should be provided in all areas where cabinets are located or liquids are being stored.

- Standard housekeeping practices should be maintained for all cabinets.
-
- A documented list should be maintained, detailing all materials located in the cabinets, with references to SDS sheets and WHIMS standards.
- All cabinets should be inventoried at least annually. All materials not being used or past due dates should be disposed of.

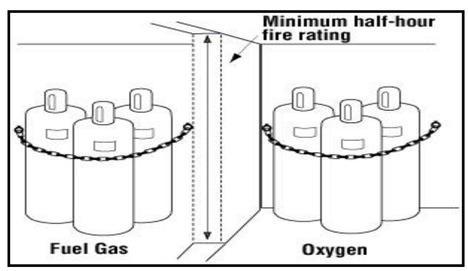
Compressed Gases

The information below is based on CSA W117.2 – Safety in Welding, Cutting and Allied Processes; and NFPA 51 – Standard for the Design and Installation of Oxygen-Fuel Gas Systems for Welding, Cutting, and Allied Processes.

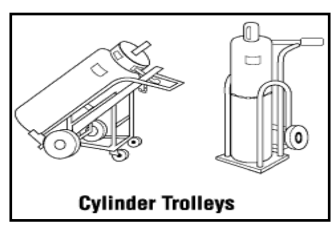
Cylinders of compressed gases should be handled and stored similarly to cryogenic substances. Containers used to store gases should meet the National Fire Protection Association (NFPA) standard, prescribed for both Canada and the United States.

There are different types of compressed gases that are used and stored within schools (and in outside storage areas). The following recommended practices are taken from various OH&S standards and apply to all schools and other areas that may utilize or store compressed gases:

- Check your fire code for guidelines regarding the storage of flammable gas cylinders;
- Store containers in a clearly identified, dry, well-ventilated storage area away from doorways, aisles, elevators and stairs;



- Post "No Smoking" signs in the area;
- Store cylinders in an upright position and secure with an insulated chain or non-conductive belt;
- Secure the protective caps;



- Ensure that the area is well ventilated. With outside storage, place on a fireproof surface inside a tamper-proof enclosure.
- Protect cylinders from contact with ground, ice, snow, water, corrosion and high temperatures.
- Store oxygen and fuel gases separately. Indoors, separate oxygen from fuel gas cylinders by at least 6 m (20 ft.) or by a wall at least 1.5 m (5 ft.) high with a minimum half-hour fire resistance.

(From CSA W117.2 – Safety in Welding, Cutting and Allied Processes; local jurisdictional requirements may vary).

- All cylinders should be secured by chains, tie-downs or other means, to help prevent accidental knocking over or falls.
- **Propane should not be stored within buildings.** It should be stored in a secure, well-ventilated area outside the building when not being used.

Heat Producing Devices

There are many ways that heat can be produced in a science lab environment. It can occur due to the combination of two or more chemicals. It can occur from radioactive materials being used and stored in classrooms. It can occur naturally based on the breakdown of some chemicals or substances and how they react during their breakdown. The storage requirements for the various chemicals, compressed gases and flammable liquids are discussed throughout this document (as well as in the accompanying SDS sheets for each product).

For the purposes of this section of the manual we will discuss the heat produced by burners (Bunsen burners in particular).

Bunsen Burners

The Bunsen burner is used in laboratories to heat things. In order to use it safely and appropriately, it is important to know the correct steps on how to set it up and operate it. A Bunsen burner can produce 3 different types of flames:

The coolest flame is a yellowish-orange color and is called the **safety flame**. It is never used to heat anything, only to show that the Bunsen burner is on. It is approx. 300°C:	The medium heat flame is called the **blue flame**. Also called the invisible flame, it is difficult to see in a well-lit room. It is the most commonly used flame. It is approx. 500°C:	The hottest flame is called the **roaring blue flame**. It is characterized by a light blue triangle in the middle and it is the only one that makes noise. It is approx. 700°C:

Procedures Before, During and After Lighting the Bunsen Burner

1. Make sure all flammable materials are a safe distance away from the burner;
2. Check the hose connections to be sure the end of the hose is tight;
3. Turn on the gas slowly and use a striker to ignite the gas, keeping your face and hands away from the top of the burner;
4. Adjust the volume of gas to a manageable level and adjust the air so you have a light blue flame;
5. If heating a container of water, use ceramic wire gauze over the tripod and adjust the height of the flame so the tip of the flame spreads over the bottom of the flask or beaker;
6. Never leave the Bunsen burner unattended when it is lighted;
7. Be aware that tripods and the top of the burner will be very hot for some period of time after use; and
8. Shut the gas off at the gas cock (rather than the needle valve at the bottom of the burner).

Lighting the Burner

<u>Step 1</u>: The first step is to check for safety - lab coat on, long hair tied back, safety glasses on, books and papers away from the flame, apparatus set up not too close to the edge of the table.

<u>Step 2</u>: The second step is to look at the holes to ensure that the holes are closed. The holes can be adjusted to let in more or less air by turning the collar.

<u>Step 3</u>: Wait for the teacher's permission, then light the match or striker. Some people prefer to turn the gas on and light the match after, but the

problem with this method is that if the match breaks or goes out, the gas continues leaking out of the tap while you get a new match.

Step 4: When you have a flame from the match, light the Bunsen burner by turning on the gas tap. To turn it on, you must first push down, then turn the tap. This is a safety feature so the taps are not accidentally pushed open. Move the match to the top of the Bunsen burner and it should light.

Step 5: Adjust the flame by turning the collar so that you have the appropriate flame for the experiment (usually the medium blue flame).

Step 6: During the experiment, stay vigilant so that if a problem occurs, you are ready to turn off the flame quickly. This means that you should not leave your table unattended.

Pointers Concerning the Bunsen Burner:

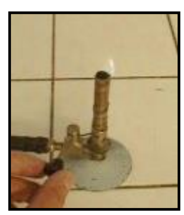
Gas is On

It is important to know whether the gas tap is on or off. No matter what the shape or color of the tap, the same rule applies: when the tap is pointing in a different direction than the tube or pipe which carries the gas, then the gas cannot flow (it is off). The blue arrow shows the direction of the gas flow. The yellow arrow shows the direction of the tap.

If the tap and the tube or pipe is both lined up and pointing in the same direction, then gas can flow through the tap. In other words, the tap is on.

Gas is Off

Why are some Bunsen burners different? You may notice that certain models have an extra tap on them with a thin tube running up the side of the Bunsen burner. This is an extra feature which allows you to turn off the Bunsen burner without turning off the gas and turn it on again without having to relight it. Such Bunsen burners look like this:



Notice the small flame on the side which stays lit even when it is turned off. This is the secret for being able to turn the Bunsen burner on again without having to relight it. Notice also that the mini tap (with the black handle) follows the same rule as the yellow tap shown above. If you know that rule, you can easily tell if it is on or off.

Anything above the flame can get very hot: the wire grill, the top of the tripod, any glass beakers and solutions you heat up. Since hot glass and cold glass look the same and hot metal looks the same as cold metal, you should always presume that something is hot. Pick up things with metal tweezers or tongs to be sure not to get burned.

Safe Operating Procedures:

1. Always wear eye protection;
2. Never use a Bunsen burner near flammable liquids or materials;
3. Tie back long hair;
4. Never have loose clothing near flame;
5. Never heat a test tube or container that has a lid, stopper or cap; and
6. Only heat items the teacher says are OK to heat.

IN CASE OF AN EMERGENCY – TURN OFF THE GAS!

Section 10

APPENDICES

NOTE: The information available from various provincial and (WCB) WorkSafeBC sources should be used as the primary sources of information when discussing safe practices within the school science lab area.

The information discussed in this section can be used to enhance the provincial and (WCB) WorkSafeBC sources, if required.

Here are the appendices included in this section of the manual:

Appendix A – **Emergency Procedures**

Appendix B – **Ventilation (Fume) Hoods**

Appendix C – **Chemical Storage Room**

Appendix D – **Health and Safety Checklist**

Appendix E – **Suggested Disposal Methods**

Appendix A – Emergency Procedures

Prepare for Emergencies

Laboratories must have written emergency procedures in place for accidental release / spills of chemicals or other harmful substances. All staff, teachers and students must be trained in these procedures, which should be posted in work areas where there is a potential for such emergencies. Employers must conduct drills annually (at a minimum) to ensure that:

- Emergency exit routes and procedures are effective and all staff, teachers and students are aware of them; and
- All staff, teachers and students are familiar with their roles and responsibilities.

Written emergency procedures should include the following:

- Requiring a record of annual drills to be kept;
- Assignment of specific responsibilities to individuals and teams;
- Instructions for immediate evacuation of all staff, teachers and students;
- Instructions for providing first aid and appropriate transportation methods to all injured staff, teachers and students;
- Appropriate emergency telephone numbers, including telephone numbers of nearby medical facilities so that they can be alerted when injured workers are on their way;
- Instructions for safely cleaning up spills and properly disposing of the waste afterward;
- A list of agencies to notify in case of a major release of a toxic or hazardous substance (i.e. (WCB) WorkSafeBC and the Provincial Emergency Program at www.pep.bc.ca);
- Reentry procedures for maintenance and cleanup work;
- Instructions for scheduling emergency drills and testing of emergency equipment; and

- Provisions for worker training (e.g. availability and use of personal protective equipment during an emergency, how to extinguish small fires, etc.).

Spill Clean-Up

Accidental release or spills of chemicals / other harmful substances must be cleaned immediately.

Workers who clean spills of hazardous materials must be adequately instructed in safe procedures. The cleanup operation must be supervised by someone who is knowledgeable in the hazards involved and the precautions required. Any personal protective equipment that will be required during emergency cleanup or escape must be stored in a condition and location that it is immediately available.

Emergency Washing Facilities (ANSI Z358.1 – Emergency Eye Wash and Showers)

Laboratories that handle or store corrosive chemicals or other chemicals harmful to the eyes or skin must have appropriate emergency washing facilities. Eyewash and shower facilities must be designed so that when activated, they provide a flow of tempered water (15° – 30° C) that continues for at least 15 minutes without requiring the use of the operator's hands.

The facilities must be within 6 – 30 metres of work areas, depending upon the level of risk. For low risk areas (where chemicals or other materials are used in a manner and quantity that present a risk of mild eye or skin irritation), any effective means of eye flushing (e.g. a drench hose) may be used instead of eyewash and shower facilities.

More specific information on risk assessment and requirements for provision of emergency washing facilities can be found in the *Workers Compensation Act*, Occupational Health and Safety Regulation (B.C. Reg. 296/97), Tables 5-2 (Risk Assessment) and 5-3 (Provision and Location of Emergency Washing Equipment.

All staff, teachers and students must know where the eyewash and shower facilities are, and must be trained in their proper use. Each facility must have signs clearly identifying the location and providing clear instructions for proper use.

Eyewash and shower facilities must be tested according to the manufacturer's instructions when first installed. They must be maintained in good working order, and plumbed systems must be full-flow-tested at least once a month. Records of maintenance work and testing should be kept.

Fire Protection

Eliminate or control all ignition sources (i.e. open flames, smoking, static discharge, etc.) whenever flammable materials are handled or stored. In addition, laboratories must be equipped with portable fire extinguishers that are immediately accessible wherever flammable materials are used or stored.

Workers who may be required to use the fire extinguishers must be trained in their use. Firefighting equipment must be maintained according to manufacturers' instructions.

A fire safety plan must be in place. The local fire department should be contacted for the specific requirements. Fire exits and exit routes must be clearly marked and kept free of obstructions at all times. All workers must be properly trained in the fire prevention and emergency evacuation procedures of their workplace.

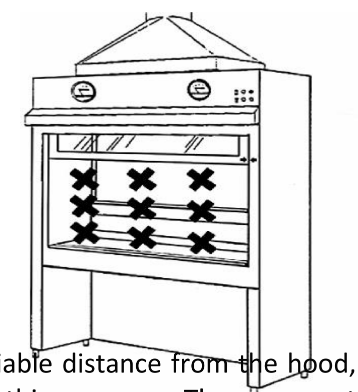
If a laboratory uses or stores hazardous materials, the employer must notify the local fire department; they need to know the nature and location of the hazardous materials and how to handle them safely. As part of the fire safety plan, there should be a list of chemicals on-site. If there is a larger quantity expected, the fire department should be notified to adjust response planning. Water-reactive chemicals should be protected from exposure in a sprinklered facility.

Appendix B – Ventilation (Fume) Hoods

CSA Z316.5-04 Fume Hoods and Associated Exhaust Systems

An important exposure control measure used in many laboratories is the ventilated work enclosure commonly called a fume hood. Fume hoods protect workers from hazardous exposure to airborne contaminants by capturing fumes, dusts, vapours, and gases generated inside the hood and discharging them safely. Because of the large amounts of air that pass through an operating fume hood, the fume hood is also an important component of the laboratory's general ventilation.

There are three common types of fume hoods:



- The air velocity entering a conventional fume hood is affected by the height of a vertically travelling sash or the lateral positioning of two or three horizontal sashes;
- A bypass fume hood maintains a relatively constant air velocity regardless of sash setting. It is useful when delicate experiments may be affected by differing air speeds at different sash settings; and
- Canopy-style fume hoods have poor capture efficiency at any appreciable distance from the hood, and the upwardly drawn fumes pass through the worker's breathing zone. They are not recommended for general laboratory use, but may be useful over furnaces or flames, where convection currents help carry fumes upward.

Using Fume Hoods and Safely Labelling

Fume hoods must be clearly labelled with any use restrictions that apply. For example, a perchloric acid fume hood must be labelled to keep combustibles out. A fume hood used for storing chemicals must be labelled to warn workers against using the hood for other purposes.

Monitoring Airflow

Air velocities across the operational face of a fume hood must be measured and recorded at least once a year. Air velocities must also be measured if the system does not seem to be working well, and after any repairs or maintenance that could have affected the airflow. As fan belts age they may loosen and slip, resulting in a loss of air flow.

Air velocities can be measured with direct air velocity reading meters, such as hot-wire anemometers. To determine the average and minimum fume hood air velocity, it is generally sufficient to measure air velocity at about nine points in a grid pattern across the operational face.

Requirements of Fume Hoods in Laboratories

Average air velocities across the operational face opening between 0.4 metres per second (80 feet per minute) and 0.6 metres per second (120 feet per minute). The face velocity must not be less than 80% of the average face velocity or greater than 120% of the average face velocity. For more information on fume hood airflow requirements refer to Section 30.8 of the *Workers Compensation Act*, Occupational Health and Safety Regulation (B.C. Reg. 296/97).
If the average or minimum measured air velocity is less than the required rate when the sash is at maximum height, lower the sash until the required air velocity is achieved; mark this height as the maximum height to which the sash may be raised. (Note: It may be possible to increase the overall ventilation rate of the fume hood to achieve required velocity over the operational face.)

If very toxic or radioactive materials are used in a fume hood and harm to workers may result from inadequate airflow, the airflow must be monitored. This involves continuous air velocity or flow measurement (using manometers, pressure gauges, pressure switches, and other devices that measure the static pressure in the air ducts), coupled with an effective warning device to alert workers if the airflow stops or is reduced to unacceptably low levels.

Cross drafts created by personnel traffic, air supply inlets, or the opening and closing of doors or windows can disrupt airflow across the operational face. Fume hoods must be located so as to prevent or minimize these and other disruptive forces. Smoke tests (using air current tubes, for example) should be made to visually assess the uniformity of air currents entering the fume hood.

The baffles of the hood should be adjusted to provide uniform airflow across the operational face.

Design and construction requirements

Fume hoods must be constructed of materials compatible with their use.

Location of controls

The controls for operating a fume hood must be located outside the fume hood and be immediately accessible to the laboratory worker. Water taps may be located inside the fume hood if the main shutoff valve is outside the hood.

Ducting

Fume hoods located in the same room or separate rooms may be connected to a common exhaust duct or manifold system if the following conditions are satisfied:

- The requirements of section 5.3.2 of ANSI/AIHA Z9.5-2003 – "American National Standards for Laboratory Ventilation" are met;
- Effective controls are installed to prevent backdrafts and pressure imbalances between rooms; and
- The ventilation design and installation is certified by a professional engineer.

Fume hoods used for perchloric acid or radioactive materials must not be connected to a manifold system. Infectious agents must be handled in biological safety cabinets that exhaust to the outdoors through dedicated ducting. Other restrictions regarding the design and use of fume hoods can be found in the *Workers Compensation Act*, Occupational Health and Safety Regulation (B.C. Reg. 296/97).

Appendix C – Chemical Storage Room

References used for this appendix are NFPA 400 – "Hazardous Materials Code", NFPA 30 – "Flammable and Combustible Liquids", and NFPA 45 – "Fire Protection for Labs using Chemicals".

The information in regard to minimum recommended practices for storage rooms was taken from the 1986-1992 BC School Building Manual (Science Education Section 3.7.3.4), as well as provincial building and fire codes which may reference NFPA 30.

Minimum Recommended Design Requirements

- One hour separation with ULC listed door (self-closing), wired glass windows must comply with provincial fire regulations, fire code, and NFPA 30 (storage of flammable and combustible liquids);
- Electrical and lighting needs to be vapour-proofed and interconnected with extraction fan (Class 1, Group D, Division 2). This applies to all electrical equipment in the enclosure, including but not limited to light fixtures, motors, fans, switches, wiring, conduits and heat detectors, etc.;
    - Class 1 – areas where flammable vapours are present;
    - Group D – flammables, solvents, etc; and
    - Division 2 – where hazard may be occasionally communicated;
- Ventilation should include an extraction fan (non-ferrous blade) to the outside wall, operated by an interconnected light switch;
- Standard recommended exhaust fan for flammable and combustible vapours is a minimum of 100 cubic feet per minute; and

- No electrical wall receptacles are permitted in a chemical storage room area.

Appendix D – Health and Safety Checklist

General Laboratory Safety - Administrative Matters

- ☐ Written safe work and emergency procedures have been developed and implemented;
- ☐ Workers have received education in the hazards of the workplace and training in all safe work and emergency procedures;
- ☐ Emergency drills are conducted at least annually;
- ☐ Regular workplace inspections are carried out;
- ☐ Special inspections are carried out after an accident or equipment malfunction;
- ☐ Unsafe conditions are corrected immediately;
- ☐ Accidents are investigated and complete investigation reports are prepared if required;
- ☐ Adequate first aid equipment and services are available;
- ☐ A formal exposure control plan has been developed and implemented, if required; and
- ☐ A written procedure for checking on employees who work alone has been developed and implemented.

Housekeeping

- ☐ All containers have complete, legible labels;
- ☐ Aisles are free of obstructions;

- ☐ Floors are free of oil, grease, and sharp objects;
- ☐ Stairs are in good condition and stairwells are well lit;
- ☐ Workers do not pipette by mouth, smoke, eat, or drink in the laboratory;
- ☐ Trash is placed in appropriate containers and is disposed of properly; and
- ☐ Cleaning and maintenance staff has been informed of hazards that may be found.

Equipment

- ☐ Equipment guards are used where appropriate;
- ☐ In-line vacuum breaks in the plumbing system are installed where necessary, and are clearly identified;
- ☐ Vacuum breaks are kept in good repair and are tested according to the manufacturer's instructions;
- ☐ Centrifuge loads are balanced by distributing samples evenly;
- ☐ Ultracentrifuge rotors and other critical components are inspected and tested regularly;
- ☐ Electrophoresis apparatus have labels warning workers of the electrical hazard;
- ☐ Equipment producing hazardous fumes is effectively vented; and
- ☐ Lockout procedures exist for equipment maintenance and servicing.

Personal Protective Equipment

- ☐ Personal protective equipment is available for all hazards encountered in the laboratory;
- ☐ Workers have been trained in the correct use of personal protective equipment;
- ☐ Workers use appropriate eye protection (safety glasses, goggles, face shields);
- ☐ Workers use appropriate gloves;
- ☐ Workers use appropriate protective footwear;
- ☐ Workers wear lab coats in the laboratory at all times, and additional protective clothing when necessary;
- ☐ Workers do not wear protective clothing outside the work area, and protective clothing is stored separately from clean clothing;
- ☐ When protective clothing is sent for laundering, the laundry operator is provided with written information about hazardous materials that may be included, as well as instructions regarding what precautions to take;
- ☐ Respiratory protective equipment is available and is used when appropriate; and
- ☐ Workers who are required to use respirators have been properly trained and tested, and the records for these are current.

Emergency Washing Facilities

- ☐ Properly designed and located eyewash and shower facilities are available and clearly identified;
- ☐ Workers know where such facilities are located, and have been trained in their use; and
- ☐ Eyewash and shower facilities are tested at least monthly, and records of maintenance and testing are kept.

Fire Protection

- ☐ Ignition sources are eliminated or controlled where flammable materials are handled or stored;
- ☐ Fire extinguishers are readily available, and their maintenance is current;
- ☐ Fire exits are unobstructed and clearly marked;
- ☐ Workers have been trained in the use of fire extinguishers, fire prevention and emergency evacuation procedures;
- ☐ Sprinklers are unobstructed and work properly;
- ☐ The local fire department has been informed about the nature, location, and safe handling procedures of hazardous materials used in the laboratory;
- ☐ A list of chemicals is available for the fire department; and
- ☐ A fire safety plan is in place.

Waste Disposal

- ☐ Assignment of specific responsibilities to individuals and teams;
- ☐ All staff, teachers and students are familiar with their roles and responsibilities;
- ☐ Emergency exit routes and procedures are effective and all staff, teachers and students are aware of them;
- ☐ Instructions are available for immediate evacuation of all staff, teachers and students;
- ☐ Instructions are available for providing first aid to, and transportation of all injured staff, teachers and students;
- ☐ Instructions are available for safely cleaning spills and proper disposal of waste;
- ☐ A list of agencies to notify in case of a major release of a toxic or hazardous substance is available (e.g. (WCB) WorkSafe and Provincial Emergency Program: www.pep.bc.ca);
- ☐ Reentry procedures are available for maintenance and cleanup work;
- ☐ Instructions are available for scheduling of emergency drills and testing equipment;
- ☐ Provisions are made for worker training (e.g. availability and use of personal protective equipment during an emergency, how to extinguish small fires, etc.);
- ☐ Hood fume(s) have been installed and the requirements of section 5.3.2 of ANSI/AIHA Z9.5-2003 – "American National Standards for Laboratory Ventilation" are met;
- ☐ Controls are installed to prevent backdrafts and pressure imbalances between rooms;
- ☐ The ventilation design and installation is certified by a professional engineer;

- ☐ There is a one hour separation with a ULC listed door (self-closing); wired glass windows comply with provincial fire regulations, fire code, and NFPA 30 – "Flammable and Combustible Liquids";
- ☐ Electrical and lighting needs to be vapour-proofed and interconnected with extraction fan (Class 1, Group D, Division 2). This applies to all electrical equipment in the enclosure, including but not limited to light fixtures, motors, fans, switches, wiring, conduits and heat detectors, etc.;
- ☐ Ventilation should include an extraction fan (non-ferrous blade) to the outside wall, operated by an interconnected light switch;
- ☐ Standard recommended exhaust fan for flammable and combustible vapours is a minimum of 100 cubic feet per minute; and
- ☐ No electrical wall receptacles are permitted in a chemical storage room area.

Waste

- ☐ Incompatible and hazardous wastes are properly segregated in clearly marked containers affixed with workplace labels;
- ☐ Cleaning and maintenance staff understands the markings used to designate hazardous wastes. Waste containers are properly labelled, tightly closed, and stored in a designated area;
- ☐ Material safety data sheets, hazardous waste profile sheets, or their equivalent are available for waste containing controlled products;
- ☐ Disposal of solvents meets all municipal, provincial, and federal regulations; and
- ☐ Sharp objects are disposed of separately from other laboratory wastes, in leak-proof, puncture-resistant "sharps" containers.

WHMIS Recommended Practices

- When chemicals are transferred from their original containers, workplace labels are prepared and applied to the new containers;
- Workplace labels are applied to each container of hazardous waste;
- A material safety data sheet is available for each controlled product used or stored in the laboratory. For hazardous wastes containing a controlled product, an SDS, hazardous waste profile sheet, or their equivalent is prepared;
- All material safety data sheets are not more than three years old;
- Workers are provided with education and training in the Workplace Hazardous Materials Information System (WHMIS);

- Workers who work with or near controlled products are provided with specific training on all such products; and
- Maintenance and cleaning staff that may be exposed to accidental release of controlled products are provided with appropriate training.

Appendix E – Suggested Disposal Methods

The following is a list of suggested disposal methods for chemicals located in science labs, classrooms and chemical storage rooms. By no means is this an exhaustive list; there are many ways of disposing used chemicals depending on type, amount, use, location and local standards.

NOTE: Before developing any chemical disposal methods, ensure that all relevant local, provincial and federal guidelines are being followed.

Classroom Management

- Make disposal methods and options a part of all laboratory instructions for students;
- For each chemical waste produced, instruct students on appropriate disposal (i.e. disposing of the substance in a disposal container or down the drain);
- Place all laboratory waste in a properly labeled container. The label should contain the date and type of waste;
- Immediately following the laboratory activity, place the waste containers in a secure location until the containers can be removed to the central storage area; and

- Some chemical waste may be recycled. Teachers should seek guidance on recycling from local safety officers or other knowledgeable administrative staff.

Drain Disposal

- Before considering drain disposal, be certain that the sewer flows to a wastewater treatment plant and not to a stream or other natural water course;
- Check with the local waste water treatment plant authority to determine what substances are acceptable for drain disposal;
- Any substance from a laboratory should be flushed with at least 100 times its own volume of tap water;
- Acids and bases should be above pH 3 minimum and below pH 8 maximum before being placed in a sanitary drain; and
- If in doubt about the proper disposal of a chemical, check with the local safety officer or refer to the Flinn system (or similar reference).

Compounds Not Suitable for Drain Disposal

For compounds not suitable for drain disposal, label and package the compound and ship by a shipper approved by the BC Ministry of Environment to a facility designated to receive chemical and hazardous waste. Even though packed, shipped, and disposed of by licensed and approved firms, generators of hazardous waste are responsible for the wastes.

Flinn (Suggested Disposal) Method

The Flinn – Chemistry Catalogue Reference Manual's suggested methods of disposal are the most quoted in North America. First and foremost is to devise a plan for disposal based on a full inventory, types of chemicals to be disposed of, amounts of chemicals and regulated practices. Much of this information is usually provided by the supplier or can be found on the accompanying SDS sheets.

Below is a good starting point in regard to developing and implementing your own chemical control and disposal system:

<u>Option A</u>: Contact your local WorkSafe (WCB) environmental organization, local, provincial or federal authorities. They may be able to make suggestions or advise about existing programs.

<u>Option B</u>: If your school is located near a college or university, that institution's chemistry department may be able to advise about the disposal methods they employ. You will want to prepare a complete list of excess substances, as the college may be able to use these materials.

<u>Option C</u>: Have you shared your list of excess materials with other neighbouring schools?

<u>Option D</u>: Contact your provincial Environmental Protection Agency (EPA). Most larger communities have local representation. Discuss the problem with this agency; perhaps they have valuable suggestions?

Option E: Try to contact an officer of your provincial science teacher's professional association. Most provinces have organized science teachers' groups. Other teachers have faced problems similar to yours; bring their experience to bear on solving your problem.

Option F: Contact the professionals at the Canadian Society for Chemistry (CSC); they may have some helpful insights.

Option G: Pay a commercial firm to assist in removing these materials (this can be an expensive option). Be sure you ask for references from such a commercial firm; there are reputable and reliable firms operating all over Canada. Ensure the firm carries the required licensing as regulated by local, provincial and federal authorities.

Option H: Is there a company in your town that also disposes of laboratory chemicals on a regular basis? If so, could you possibly piggyback your excess chemicals with theirs and split the cost? This is an option many teachers have found very useful.

Option I: You may wish to do the disposal work yourself. If you elect this option, you will want to examine the disposal methods provided in the Flinn – Chemistry Catalogue Reference Manual.

A full plan should be devised before starting any chemical disposal program. If you will take some time to properly package many of the hazards on your shelf, that will allow you time to examine options.

If you have elected to use the disposal methods published in the Flinn – Chemistry Catalogue Reference Manual, there are some further considerations that need your attention, namely:

1. Have you checked with regulatory officials in your area regarding these procedures? **Do not use these procedures if local regulatory officials have not approved**.
2. You will need to make a list of the safety aids required for these procedures (e.g. fume hood, apron, chemical splash goggles, fire extinguisher, gloves, etc.).
3. Never work alone! Find a competent assistant and proceed to work as a team.
4. If a particular method is confusing or you are not familiar with the chemistry involved, do not proceed; contact Flinn and they can assist you: 1-800-452-1261.
5. Do some practical cost analysis. In many cases, the procedures require the use of large quantities of neutralizing chemicals and other expensive materials. You may find that your cost analyses may cause you to go back and examine disposal by paying a commercial firm to remove the chemicals.
6. Always practice your intended disposal activity on a tiny sample of the targeted substance before moving on to handle larger volume. A reaction that liberates enormous amounts of heat may require that your vessel be immersed in an ice bath to better control the temperature. You

will only make these discoveries if you conduct a trial with a very small sample before fully proceeding.

7. All of these procedures are best done in a very well ventilated laboratory and preferably inside a good, efficient fume hood. If you elect to perform a procedure outdoors, then stay upwind of the reaction and be sure your activities do not disturb or threaten your school's neighbours.

8. Make a checklist of all items needed for a particular method before you start the procedure, and have all materials readily available.

In summary, chemical removal and disposal are serious undertakings. Examine your options carefully and responsibly.