SASKATCHEWAN RIVERS PUBLIC SCHOOL DIVISION
SCHOOL SCIENCE LAB SAFETY AND RESOURCE MANUAL

Saskatchewan Rivers Public School Division

Excellence for Every Learner

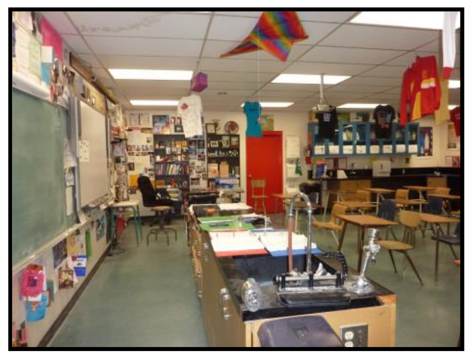

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TABLE OF CONTENTS

TABLE OF CONTENTS (CONT.)

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 Classrooms.

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 Science Lab 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 / Classroom environment.

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

1. Ample space is provided for experiments and equipment

2. Permanently placed equipment is fastened to the floor or work areas.

3. Safety areas are clearly marked when experiments are taking place.

4. Approved PPE (Personal Protection Equipment) is worn when required.

5. Standard emergency stations are provided.

6. All safety procedures are followed at all times.

7. Standard storage is provided for all onsite chemicals, compressed gases and flammable liquids

8. Students are not allowed in designated preparation areas.

9. Full safety training is provided on all equipment before first use.

10. Enforcement policies are provided which allow teachers to remove students from School Science Labs and Science Lab Classrooms if they are thought to be a danger to the teacher or other students.

Section 2

Source Materials, Standards, Codes & Recommended Practices

- The purpose of this manual is to discuss the safe and recommended practices for School Science Labs and Science Lab Classrooms design and safety. The information in this manual includes various source materials in regards to School Science Labs and Science Lab 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
- Worksafe, BC & OSHA Standards
- Other related standards, regulations and documentation

Section 3

Responsibilities of District, Staff and Students

The designed responsibilities for every level of operation within the School Division in regards to safety in and around School Science Labs should follows the basic idea and recommended practice as discussed in (WCB) Worksafe recommended practices.

The Division/Maintenance department is responsible to ensure they provide a safe work place for the staff/teachers.

The teachers are responsible to provide training, direction and supervision to the students to help mitigate potential to the students.
The students are required to follow all the rules and regulations within the School Science Labs and Science Lab Classrooms and to ask questions if they have any concerns in regards to safety or operations.

Expanded Responsibilities are discussed further, based on the following:

- Employer/Division/Maintenance
- Staff/Teacher/Supervisor
- Student/Employee

GENERAL

- 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 or 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 is everyone's business.
- Following is a list or responsibilities as adapted from the **Workers' Compensation Board in their Work Safe Online document entitled "Safety on the Job is Everyone's Business"**.
- **(website:http://www.worksafebc.com/publications/Health_and_Safety_Information/by_industry/assets/pdf/safetyonthejob.pdf)**

EMPLOYER (SCHOOL DIVISION)

- To provide a safe environment;
- Take action immediately when the worker or supervisor 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 (see various Schools Protection Program Manuals);

- Provide adequate First Aid facilities and services;
- 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 such as 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;
- Complete a School Protection Program Incident Report each time an accident occurs.

EMPLOYEE (STUDENT)

- Know and follow safety and health procedures affecting your work;
- If you don't know, ask for training before you begin work;
- Work safely and encourage your classmates to do the same;
- Correct or immediately report any unsafe conditions to your teacher;
- Take the initiative – 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 of this section include

- Safety and Health Inspections
- Hazard Analysis

PURPOSE OF SAFETY AND HEALTH INSPECTIONS

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

- 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 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 additions of new equipment. One way of keeping aware of hazards is through continuous inspections.

PURPOSE OF INSPECTION

- To spot potential hazards before an incident occurs;
- To assess the hazard;
- To find improvements and corrections to improve overall operations and increase effectiveness;
- Do all of the above every day.

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 any unsafe situations (if correction is not possible).

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 of their shop/lab/facility.

Department Head or Supervisors

A school/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 may 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;

- 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 be a benefit to the particular facility. (See Annex Section).

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 are 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 points are stored properly (i.e., chemicals, flammable liquids, acids and others 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' consistent preventative maintenance in the lab/facility and with tools 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;
- Establishing control measures (special procedures, guarding, PPE);
- Set up equipment and experiments 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 check out specific equipment manual for proper procedures, where required.

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 equipment and experimental devices;
- Faulty devices and equipment;
- New or altered processes;
- Potential for injury;
- Severity of injury;
- Frequency of incidents.

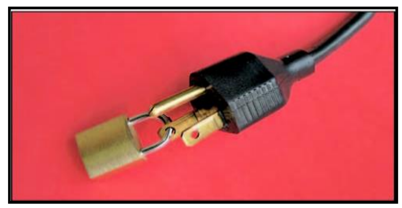
The Process of Hazard Control

The four processes in hazard control are:

1. Spot the hazard.
2. Assess the risk.
3. Find a safer way.
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 Committee). Based on problems uncovered and recommendations by Workplace Safety and Health, they must decide on the best course of action.

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

Section 5

General Safety – PPE (Personal Protection Equipment)

NOTE: The information available from various "Provincial and (WCB) Worksafe Resources" should be utilized as the primary sources of information when discussing safe practices within the School Science Lab area.

The information discussed in this section can be utilized to enhance the "Provincial and (WCB) Worksafe Resources"" if required.

PPE does not take the place of such engineering controls as substitution, isolation and ventilation. PPE are 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, vapors 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 (built in safety equipment) 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).
- 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.

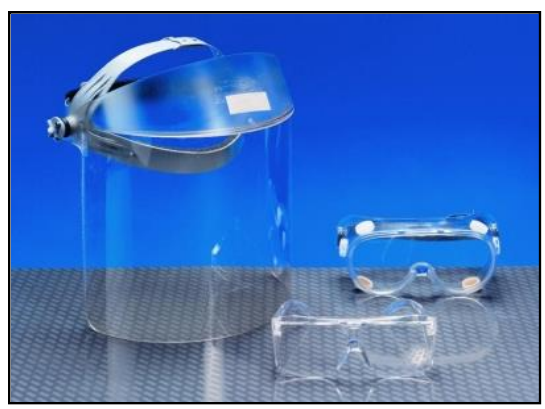
DUCATION
Unless students are educated in the use and care of PPE, it may do little to fulfill its intended purpose.

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
In School Science Labs, students' eyes can be exposed to a variety of hazards (i.e., chemical vapors, splashes of corrosive liquids, exposures to irritants, flammable fuels and harmful radiation). BC Workplace Safety and Health 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.



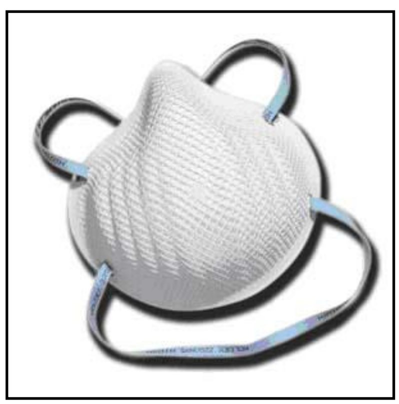
Hearing Protection

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

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

Statistics indicate injuries to the arms, hands, and fingers account for more than a quarter of all disabling mishaps. The hazards in the 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, exposures to vapors, 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, materials and during experiments. There are many types of gloves that are suitable for chemicals, radiation, heat and flame.

Body Protection

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) Worksafe Resources" should be utilized as the primary sources of information when discussing safe practices within the School Science Lab area.

The information discussed in this section can be utilized to enhance the "Provincial and (WCB) Worksafe Resources"" 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 located so it is easily accessible and 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	Descriptions
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 a minimum of once every month.
Sand bucket (approximately 20 L of sand) *NOTE: May replace with Class D type fire extinguisher if required*	For small fires and possible combustible metal fires only.
One pair of safety goggles, 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 where required	Respirators or masks should be used based on the expected and possible exposures, including but not limited to vapors, mist, dust and other potential exposures.
One pair of safety/beaker tongs	Should be used with heat resistant gloves.
One fume hood	The fume hood should provide standard air velocities 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 utilized in conjunction with experiments.
Spill kits	Utilized to absorb chemical and other spills in the Science Lab or Science Classroom.
Equipment	**Descriptions**
Waste Disposal – Glass	Broke glass, can be cut and disposed of in designated containers.
Waste Disposal – Organic Solvents and Soluble Chemicals	Organic solvents and flammable wastes must be collected in separate, tightly covered, listed containers and should be disposed of based on municipal, provincial and federal regulations.
Waste Disposal – Biological Waste	Biological waste must be segregated and disposed of safely. Municipal, provincial and federal rules may apply.

ULC listed self closing waste container	For disposal of materials soiled or contaminated with flammable chemicals or materials.
Neutralizing solutions	Dependent on chemicals being used. May require small amounts of neutralizing solutions to be used in the event of spills.
Laboratory first aid kit	Should contain 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 Science Lab Classroom.

SAFETY STATION REQUIREMENTS

This information in regards to minimum Safety Safety Station recommended practices was taken from various OH&S sources, Worksafe sources & others:

Eyewash station

Emergency shower

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

SCIENCE LAB FACILITY

NOTE: The information available from various "Provincial and (WCB) Worksafe Resources" should be utilized as the primary sources of information when discussing safe practices within the School Science Lab area.

The information discussed in this section can be utilized to enhance the "Provincial and (WCB) Worksafe Resources"" if required.

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

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

RECOMMENDED (SAMPLE) FACILITY LAYOUT & EQUIPMENT

Facility considerations when designing a Science Lab & Science Lab Classroom

1. Science Lab and Classrooms activities generally require a flat, horizontal work space.

2. To help ensure proper supervision is provided. The classroom and lab space should be so designed to allow the teacher / instructor to have clear unobstructed sight lines to all students.
3. The number of students that may safely work in a Science lab of Science lab classroom should be determined and governed by local Fire and Building code regulations. The recommended gross space allocated per person in the classroom is 4.6 sq.m.
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 that the area does prove to be hazardous due to design.
5. Science lab areas and science classrooms should be provided with standard and regulated storage cabinets, cupboards, storage rooms, chemical and wash sink areas, emergency equipment areas, designated chemical storage areas, etc.
6. All Science lab classrooms and science labs should be adequately ventilated.
7. When designing or re-designing a designated Science lab or Science lab 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 will meet the needs of teachers, staff and students.

Facility Design and Safety Equipment

The following checklist is provided as a guideline only. Further information if required is available through Provincial, (WCB) Worksafe 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?
- ❒ The general light level is 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 detectors and heat detectors installed in laboratories, science preparation rooms, chemical storage areas, waste disposal areas, and any other high-risk areas?
- ❒ Is at least one emergency eyewash station located in areas where corrosive chemicals are used, according to Occupational Health and Safety regulations for workers?

Exits

- ❒ Does the room have two exits, both with doors that open outward and have reinforced glass viewing windows or peepholes?
- ❒ Do doors open easily with standard exit hardware provided if required?
- ❒ 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 a material with a low flame-spread rating; e.g., drywall?
- ❒ Are floors even, free of cracks and have a nonskid surface (sheet flooring is preferable to tiles or carpets; tile floors should be covered with a nonskid wax)?
- ❒ Are laboratory bench surfaces made of material resistant to acids, alkalis, solvents and temperate 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 15 L per second per occupant?
- ❒ Is the exhaust ventilation system is separate from that of the chemical fume hood?
- ❒ Is the hood(s) of the exhaust ventilation system is/are 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 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 all power outlets meet 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 outlets within 1.5 metres of water are equipped with Ground-Fault Interrupters?
- ❐ Are fume hood controls are located outside the fume hood in an immediately accessible area?

Plumbing

- ❐ Is plumbing free of leaks or cracks, and drains are made of chemical resistant material?
- ❐ Are counter tops are lipped toward the sink?
- ❐ Is a plumbed-in emergency eyewash station and/or shower is/are 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

- ❐ Are chemical storage area adequate in size, well ventilated, secured from student access, built with material having a low flame-spread rating, and has an adequate drain at the lowest point?
- ❐ Are adequate areas for the long-term storage of laboratory equipment and 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? They should also allow for storage of MSDSs, 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

CHEMICALS

NOTE: The information available from various "Provincial and (WCB) Worksafe Resources" should be utilized as the primary sources of information when discussing safe practices within the School Science Lab area.

The information discussed in this section can be utilized to enhance the "Provincial and (WCB) Worksafe Resources"" if required.

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

- Chemicals in Labs
- WHMIS
- Education & Training
- Chemical Storage
    a. Suggested Practices in the Storage and Handling of Laboratory Chemicals
    b. General Rules for Chemical Storage
    c. A Suggested Model for Chemical Storage
- Managing Spills
- Disposal of Materials, Chemicals & other Related Substances – Suggested Methods (See Appendix Section)

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 to that can lead to injury to both students and staff.

When developing a system to determine what chemicals are needed to meet the requirements for a High School Science Lab, at a minimum the following procedures should be applied.

1. Take an inventory
2. What Chemicals do you really 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
7. Develop a Chemical Disposal Program

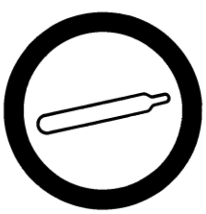
WHMIS (Workplace Hazardous Materials Information System)

The purpose of a WHIMS program in all workplaces is to ensure that all person 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 Material (Including Biohazardous Materials)
5. Corrosive Materials
6. Dangerously Reactive Materials

The classes and symbols WHMIS uses to identify hazardous materials are:

Class A



Compressed Gas

Classifying material which is a gas at normal temperature and pressure, packaged under pressure in a cylinder or other container. Many of our laboratories and work areas use cylinders of various sizes and content such as compressed air, hydrogen or nitrogen.

Class B

Flammable and Combustible Materials

Classifying material that will ignite and continue to burn in air if exposed to a source of ignition. This class includes gases, aerosols, liquids and solids. Many laboratory solvents and cleaning materials used on campus fall into this class.

Class C

Oxidizing Materials

This symbol identifies material that releases oxygen or other oxidizing substances and thereby contributing to the combustion of other flammable materials. Oxidizers such as chlorine, nitrogen dioxide and hydrogen peroxide are found in many of our laboratories.

Class D These symbols represent the class of materials that pose the greatest potential hazard to our life and health.

Division 1: Materials Causing Immediate and Serious Toxic Effects

The skull and cross bones identifies acutely toxic material. These materials can severely damage our health in a single overexposure. Fortunately, few of our work areas contain this type of material. Examples are cyanide compounds, styrene.

Division 2: Materials Causing Other Toxic Effects

This unique symbol identifies material that poses a threat to our health through long term exposure. Further, this material may be a suspected carcinogen or have other health damaging properties. Our labs, work areas and shops contain materials marked with symbol.

Division 3: Biohazardous Infectious Material

This distinctive symbol identifies material that presents the risk or danger of biological or viral infection on contact. Very few areas of the University use or produce material marked with this symbol. Containers for biomedical waste and used syringes, needles and sharps are marked with this symbol.

Class E

Corrosive Material

Corrosive material can attack metals and other substances and can cause permanent damage to human tissues and organs. Fumes from these material can also damage our internal organs. Strong acids, ammonia and fluorine are examples of corrosives.

Class F

Dangerously Reactive Material

This symbol identifies dangerously reactive materials. These materials may react violently under certain conditions or react violently with water. Few of our work areas use or store these materials.

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

Proper Labels (supplier and workplace labels)
Material Safety Data Sheets (MSDS sheets)
Education and Training

LABELS

Supplier Labels

Suppliers are required to provide labels for the following supplies:

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

Information required on a suppliers label	**Laboratory Chemical**	**Laboratory 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 MSDS	X		X	X
English (and French)	X	X	X	X

Workplace Labels

If a chemical is transferred from its original container and is for use in the Science Lab, the employer or designated person must ensure that the contents are clearly identified on the container.

Workplace Labels must include the following:

- The product identification
- Safe handling information
- Reference to a material safety data sheet

Material Safety Data Sheets (MSDS sheets)

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

MSDS sheets need to be available at all times as a reference tools for persons working in the environment, occupational health and safety committees and in some case 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 at least the following information:

- Elements of the WHMIS (Work Hazardous Materials Information System) program
- Hazards of the chemicals being used
- Rights and responsibilities of those persons working in the environment
- Information required on labels and material safety data sheets (MSDS), and the significance of the information

Chemical Storage

Some 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 liter) of each product unless you have an area designed and equipped for more. We suggest you 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, e.g., acids and bases in the 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 and secured storage area for chemicals.

8. All chemicals should be stored in chemically compatible families. (See Chart's on following pages).

9. Avoid storing chemicals on shelves above eye level.

10. The storage area and cabinets should be labeled to identify the hazardous nature of the products stored within.

11. Proper type (Multi-Purpose ABC) and size (minimum 2A10BC) fire extinguishers, in working order, should be in the chemical stores area.

12. Shelving above any work area, such as a sink, should be free of chemicals or other 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 from 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 before using any chemical product.

20. Know applicable local regulations before disposing of chemicals.

21. Never store chemicals in a standard (non-explosion-proof) refrigerator.

22. Do not store chemicals in a fume hood.

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

24. Glycerin should be available only to the instructor.

25. Water-reactive products (sodium metal, 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 stores area.

28. Post emergency telephone numbers in the chemical stores area. Ideally, a telephone should be located in this area 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 stores area.

32. Discourage the purchasing of large containers of chemicals and dispensing into smaller containers.

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

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

General Rules for Chemical Storage

Criteria for Storage Area

- Store chemicals inside a close able 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 first by COMPATIBILITY—not alphabetic succession (See Chart's on following pages).

- 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 Chart's on following pages).
- Store water sensitive chemicals in a water-tight cabinet in a cool and dry location segregated from all other chemicals in the laboratory.

Storage Don't's

- Do not place heavy materials, liquid chemicals, and large containers on high shelves.
- Do not store chemicals on tops of cabinets.
- Do not store chemicals on the floor, even temporarily.
- Do not store items on bench tops 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 the container with a paper towel before returning it to the storage area. Properly dispose of the paper towel after use.

A Suggested Model for Chemical Storage

This model 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
- using an effective ventilation system

A chemical storage room must be secure to prevent theft and unwarranted use of chemical stock. A separate key from those used to enter classrooms or preparation areas is essential. Allow only authorized personnel to have access to the chemical storage room.

The room must be adequately vented as per standards and codes with a fan that runs continuously. Install explosion-proof lights, switches, and fan motor housing to prevent fires due to electrical shorts or sparks in faulty switches. Ground fault interrupter (GFI) circuits should be installed, especially near sinks. Construct ceilings and walls of gypsum boards 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 Senior Years 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 examine closely 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 Alcohols, 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, Anhydrides, 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 Include

- avoiding floor chemical storage (even temporarily)
- avoiding chemical storage on top of shelf unit
- avoiding chemicals stored above eye level
- fastening shelf assemblies securely to a wall (avoid island shelf assemblies)
- making shelving assemblies of wood
- providing lips on all shelves to prevent roll-off
- avoiding metal, adjustable shelf supports or clips (fixed, wooden supports are preferred)
- storing both inorganic and organic **acids** in a dedicated acid cabinet with doors
- storing **nitric acid** isolated from other chemicals
- storing flammables in a dedicated metal cabinet with doors
- storing extremely toxic poisons in a locked cabinet

Managing Spills

Deciding how to handle a spill first requires understanding 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 MSDS sheets that should be accessible to users at all times, and 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 releases 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.

In the case of spills of acids and bases, local action by knowledgeable staff can be taken to neutralize the spill using materials prepared for that purpose. Once neutralized, the products can then be cleaned up and disposed.

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

Corrosive Liquids

Less serious spills of corrosive liquids can be handled using the following steps.

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 apply a spill kit pillow. For bases, sprinkle boric acid or citric acid on the spill, or apply a spill kit pillow. Test with pH paper to ensure the substance is completely neutralized.
4. Dilute with plenty of water and mop up using an absorbent cloth.
5. Wash contents down the sink and clean spill area with water. Wipe dry with paper towels.

   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 sent for disposal.

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 the contaminated absorbent into a heavy gauge garbage bag or plastic bucket with lid.
4. Wash the spill area with soap and water, using a disposable cloth.
5. Dispose of the contaminated cloth in the same garbage bag.
6. Allow to evaporate under the fume hood.

Other Liquids (excluding mercury)

Water-soluble liquids

1. If necessary, contain with towels, asbestos-free vermiculite, bentonite or diatomaceous earth.
2. Dilute with water.

3. Mop up using paper towels 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 MSDS sheets for final disposal details.

Water-insoluble liquids

1. If necessary, 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 towels.
4. Discard contaminated towels or cloth. Check MSDS sheets for final 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. Determine appropriate disposal procedures from the MSDS sheets.

Disposal of Materials, Chemicals & other Related Substances – Suggested Methods (See Appendix Section)

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 before disposal. Autoclave liquid cultures and pour into a drain with large amounts of water. Dispose of syringes, needles, scalpels, and razor blades in a metal or thick plastic container which is labelled.

Disposal of Chemicals - Suggested Methods Only

NOTE: The following information contains and discusses suggested methods of Chemical Disposal only. Before a system is put into place local, provincial and federal guidelines and regulations should be reviewed and adhered to at all times.

(See Appendix area for more suggested information on Disposal of Chemical methods)

The four methods of dealing with chemical wastes include

- flushing into drains
- landfilling
- incinerating
- reclaiming

Do-it-yourself disposal can be costly. Useful references for disposal on your own are

- Prudent Practices for Handling Hazardous Chemicals in Laboratories
- Flinn Chemical 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. Mercury is highly toxic in small amounts. A broken thermometer should be cleaned up immediately, using a mercury spill kit, 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 by-laws or special waste 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 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 more convenient to use and are recommended.**

- Vermiculite (6 kg) and activated charcoal (1 kg) mixture
- bentonite or Kitty 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
- metal containers for flammable wastes

Disposal Through a Commercial 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 (e.g., jar, tin) in a heavy clear plastic bag (freezer bags work well)
- sealing the bag and labelling the contents
- packing the bag in a box using vermiculite, styrofoam chips, or similar packing material
- labelling, then sealing the box with tape
- keeping acids and reducing agents separate (if the quantity of disposables is large, pack chemicals from different hazard groupings in separate boxes)
- delivering or having all materials picked up by the waste management company
- avoiding packing explosive or highly reactive substances

Teaching About Spill Clean-up

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

Sample Lesson Plan

Time: 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. 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 clean-up procedure and insist on the importance of telling the teacher immediately of an accident, spill, or contact of chemicals with skin or clothing.
- **Demonstration:** Show students how to clean up an ethanol spill.
- **Practice:** Use simulated spills (water) to have students practice clean-up 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 on these procedures on safety quizzes or examinations.

NOTE: For more information on suggested methods of Chemical Disposal. See the Appendix section at the end of this manual.

Section 9

Hazards

HAZARDS

NOTE: The information available from various "Provincial and (WCB) Worksafe Resources" should be utilized as the primary sources of information when discussing safe practices within the School Science Lab area.

The information discussed in this section can be utilized to enhance the "Provincial and (WCB) Worksafe Resources"" if required.

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

Specific Hazards and Related areas we will cover 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 Exposures

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 container, 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 or grinding solids or unnecessarily transferring powders, which 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 does 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, or 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 clean-up 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 insidious hazards during the safety inspection process.
- Prepare an inventory of insidious 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 build-up of toxic, flammable or corrosive materials.
- Keep appropriate clean-up 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, nonmetal halides, dehydrating agents, halogens and oxidizing agents. The most serious corrosion 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 MSDS sheets and other related documentation.

Explosive Substances & Reactive Chemicals

Concentrated forms of unstable substances that have the potential to explode pose too great a risk to warrant use and should not be kept in schools. Some explosive substances in lower concentrations, such as hydrogen peroxide, are relatively safe. For more information on explosive substances and reactive chemicals refer to the NSDS 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 in this section of the manual. 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 (if these are still around)
- mixed chemicals that slowly react to form toxic products, particularly mixtures of waste materials
- neglected containers of dried solutions and residues of chemical products from past demonstrations and activities
- 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 moisture in the skin
- interfere with chemical reactions of the body; e.g., CO replaces O2 in hemoglobin
- 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 (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
- 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. 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
- 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 also a major concern.

Given the hazards of mercury, it is not recommended for use in Alberta schools. Mercury thermometers should no longer be used in schools because of potential 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.
- 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 clean-up 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 clean-up of mercury spills is essential or cumulative exposure to mercury vapours can cause irreparable harm to those working in the area.

The clean-up 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-up spills using commercial spill kits, while others specifically restrict clean-up to professionals such as those at Hazmat Clean-Up. Check your school board's policy on mercury spill clean-up before proceeding with the actual process. If board policy allows staff clean-up, 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 / 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
- 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 are 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 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 Government Industrial Hygienists or the International Agency of Research on Cancer. These substances will also be categorized under WHMIS as Class D2.

Health Canada has tabled a list of substances assessed for carcinogenicity on its Web site at http://www.hc-sc.gc.ca/ewh-semt/occup-travail/whmis-simdut/compliconform/carcinogenesis-carcinogenese_e.html. The Web site also has links to agencies to enable searches of the most current information.

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 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 learner 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 build-up 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 are 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, 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 abrasion on arms, legs and head.
- **Heavy equipment and materials stored overhead** - An accident can cause "mechanical" injuries to the back, arms, legs and head if a heavy overhead item slips while being moved. Mechanical injuries are the result of excessive forces applied to the body.

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 modification 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. Improperly made 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 that is not properly insulated and grounded 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 set-ups 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).

A 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.**

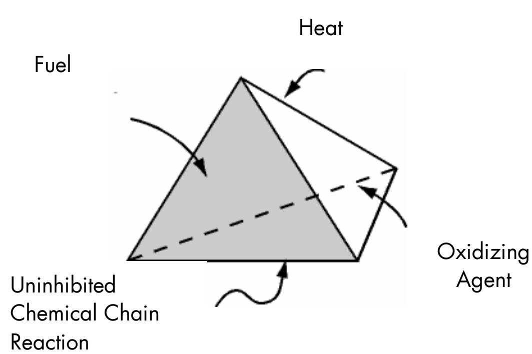
Teachers/Lab Technicians must:

- 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, such as centrifuges, vacuum pumps, rock saws, grinders and demonstration motors, 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;
- Indicate clearly a **No Crowding Zone** around all major equipment, within which there must only be the equipment operator;
- Clearly tag all faulty equipment so it will not be used before it is repaired;
- Arrange for modification 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 inspection and completion of dated and signed inspection sheet;
- Store all heavy items as close to the floor as possible

Fires

Burning is the rapid oxidation of a fuel by an oxidizer (usually 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 the four interrelated components: fuel, oxidizer, an energy source and uninhibited chemical chain reaction. These four 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;
- 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 probability possible. Elements of a successful fire control program include:

- adequate education of students in the hazards of fire;
- the use of proper lab procedures;
- the maintenance of proper chemical storage facilities and;
- the provision and maintenance of effective fire control equipment.

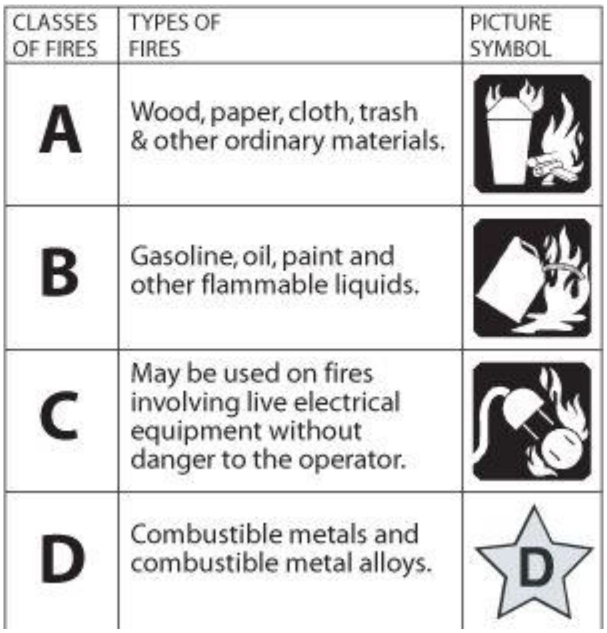
Fire Safety Equipment

- **Fire Blanket** - are made of fire proofed wool/rayon material and are not to be used where spillage and fire spreading is possible.
- **Sand bucket and scoop** 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 all four of them, to extinguish the fire. Usually, however, an extinguisher either cools the area so a fire will not burn (remove energy source) or 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 also be used.
Class B - fires involving flammable liquids such Dry chemical foam	CO_2, Multi – Purpose Class (ABC) extinguishers can also be used.

Class C - fires involving electrical equipment.	Non-conducting agents such as dry chemical or carbon dioxide. Multi – Purpose Class (ABC) extinguishers can also be used.
Class D – fires involving combustible metals, such as magnesium, sodium, lithium, 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 - have a **complete** check at least annually.
- Never re-use a used extinguisher - have it recharged.
- Have all extinguishers clearly marked as to class and use.
- Locate conspicuously - have location marked with signs—preferably near an exit door.
- Mount at an accessible height.
- Locate convenient to area of use.
- Check monthly.

Some Don'ts

- Don't throw water over a chemical fire.
- Don't use a fire extinguisher on standing beakers and flasks.
- Don't 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 both in Canada and the United States.

Flammable and Combustible Liquid Storage

- The information in regards to minimum recommended practices for storage of flammable and combustible liquids is taken from several standard and regulations including BC Fire Code, NFPA 33 (spray applications) and NFPA 30 (storage of flammable and combustible liquids).

- These codes and standards dictate the minimum precautions to take in regards to storage, handling, transportation, ventilation and general housekeeping.

- All flammable liquids when not in use 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 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 MSDS sheets and WHIMS standards.

- All cabinets should be inventoried a minimum of once per year. All materials not being used or passed due dates should be disposed of accordingly.

Compressed Gases

Cylinders of compressed gases should be handled and stored in a similar fashion to cryogenic substances.

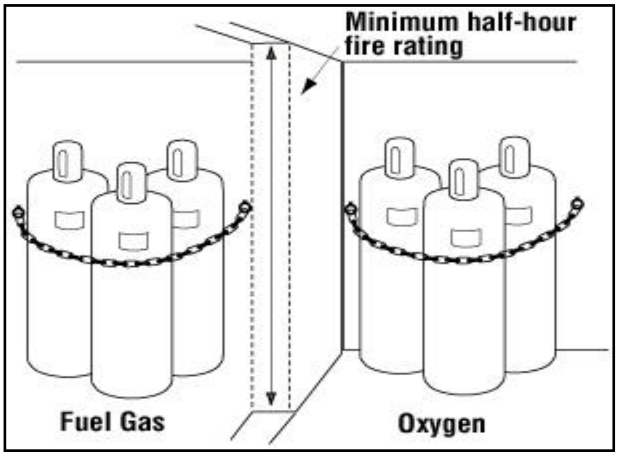
Containers used to store gases should meet the National Fire Protection Association (NFPA) standard, prescribed for both Canada and the United States.

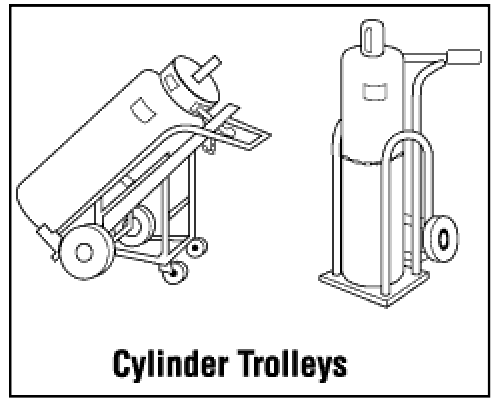
There are different types of compressed gases that are utilized and stored within schools and in outside storage areas.

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 the 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 and enclose in 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 W117.2-06 “Safety in welding, cutting and allied processes”. Local jurisdiction requirements may vary).
- All cylinders should be secured by chains, tie down or other means to help prevent accidental knock 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 there breakdown. The storage requirements for the various chemicals, compressed gases and flammable liquids are discussed throughout this document as well as in the accompanying MSDS 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 Burner

Introduction:

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 yellow / orange color. It is approximately 300°C. It is never used to heat anything,	The medium flame, also called the **blue flame** or the invisible flame is difficult to see in a well-lit room. It is the	The hottest flame is called the **roaring blue flame**. It is characterized by a light blue triangle in the middle and it is

only to show that the Bunsen burner is on. It is called the **safety flame**.	most commonly used flame. It is approximately 500°C.	the only flame of the 3 which makes a noise. It is approximately 700°C.
		

Procedures before, during and after lighting of 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 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. Adjust the air so you have a light blue flame.
5. If heating a container of water, use a 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.
8. Shut the gas off at the gas cock rather than the needle valve at the bottom of the burner.

Lighting the Burner

Step 1
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...

Step 2
The second step is to look at the holes. Check that the holes are closed. The holes can be adjusted to let in more or less air by turning the collar (see below).

Step 3
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. The problem is if the match breaks or goes out, the gas is leaking out of the tap while you get a new match.

Step 4
Light the Bunsen burner. When you have a flame from the match, turn 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. Approach 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.

Some pointers concerning the Bunsen burner:

How is it possible to know if 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. In other words, it is off. The blue arrow below shows the direction of the gas flow. The yellow arrow shows the direction of the tap.

Gas is Off

Gas is On

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

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 each time. 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 the flame
5. Never heat a test tube or container that has a lid, stopper or cap
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) Worksafe Resources" should be utilized as the primary sources of information when discussing safe practices within the School Science Lab area.

The information discussed in this section can be utilized to enhance the "Provincial and (WCB) Worksafe Resources"" if required.

Here is what we will cover 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 for accidental release or 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 at least once a year to ensure that:

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

A record of the drills must be kept.

Written emergency procedures should include the following:

- Assignment of specific responsibilities to individuals and teams
- Instructions for immediate evacuation of all staff, teachers and students
- Instructions for providing first aid to and transporting injured all 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, e.g., (WCB) WorkSafe and the Provincial Emergency Program (www.pep.bc.ca)
- Re-entry procedures for maintenance and clean-up work
- Instructions for scheduling emergency drills and testing of emergency equipment
- Provisions for worker training (for example, on the availability and use of personal protective equipment during an emergency, and how to extinguish small fires)

Spill Clean-Up

Accidental releases and spills of chemicals or other harmful substances must be controlled immediately.

Workers who clean up spills of hazardous materials must be adequately instructed in the safe procedures. The clean-up 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 clean-up or escape must be stored in a condition and location so that it is immediately available.

Emergency Washing Facilities

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 either 6 metres or 30 metres of work areas, depending on the level of risk. For low-risk workplaces, 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.

For specific information on risk assessment and requirements for provision of emergency washing facilities, see Tables 5-2 and 5-3 in the Occupational Health and Safety Regulation.

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 (such as open flames, smoking, static discharge, and so on) whenever flammable materials are handled or stored.

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.

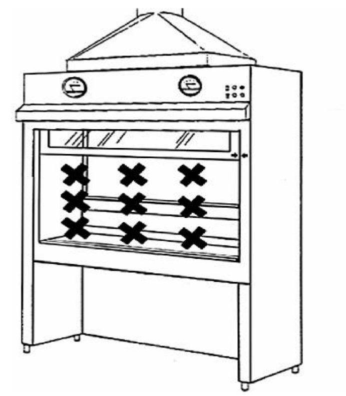
A fire safety plan must be in place. The local fire department should be contacted for the specific requirements. Fire exits and exit routes must be clearly marked and kept free of obstructions at all times. All workers must be properly trained in the fire prevention and emergency evacuation procedures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

If a laboratory uses or stores hazardous materials that may endanger firefighters, the employer must notify the local fire department. The fire department needs 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 of any product at a given time, the fire department should be notified for their response planning. Water-reactive chemicals should be protected from exposure to water in a sprinklered facility.

Appendix B – Ventilation (Fume) Hoods

Fume Hoods

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 system.



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 the 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.

- 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 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[4] 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, for example, they may loosen and slip, resulting in a loss of air flow.

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

Fume hoods in laboratories must provide

Average air velocities across the operational face opening of 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 Occupational Health and Safety Regulation.

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 the 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 air flow, the airflow must be continuously 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 the airflow across the operational face. Fume hoods must be located so as to prevent or minimize these and other disruptive forces. Smoke tests (for example, using air current tubes) 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 a 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/A IHA Standard Z9. 5 -2003, Laboratory Ventilation* are met.
- Effective controls are installed to prevent backdrafts and pressure imbalances between rooms.
- 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 Occupational Health and Safety Regulation.

Appendix C – Chemical Storage Room

The information in regards to minimum recommended practices for finishing 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 (see below).

Minimum Recommended Design Requirements

- One hour separation with ULC listed door (self-closing), wired glass windows comply with provincial fire regulations, Fire Code, NFPA 30 (storage of flammable and combustible liquids).
- Electrical & Lighting – vapour-proof sealed and interconnected with extraction fan (Class 1, Group D, Division 2). Applies to all electrical equipment in enclosure including, but not limited to, light fixtures, motors, fans, switches, wiring, conduit, heat detectors, etc.
- Class 1 –areas where flammable vapours are present.
- Group D – flammables, solvents, etc.
- Division 2 – where hazard may be occasionally communicated.
- Ventilation – extraction fan (non-ferrous blade) to outside wall, operated by light switch (interconnected).
- Standard recommended exhaust fan for flammable and combustible vapours is a minimum of 100 cubic feet per minute.
- 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 are being 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 accident 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.
- A written procedure for checking on employees who work alone has been developed and is being 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 proper containers and disposed of properly.
- Cleaning and maintenance staff have been informed of hazards that may be found in the laboratory.

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 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.
- 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 proper eye protection (safety glasses, goggles, face shields) when appropriate.
- Workers use gloves when appropriate.
- 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 store them 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 with it as well as precautions to take.
- Respiratory protective equipment is available and is used when appropriate.
- Workers who are required to use respirators have been properly trained and fit-tested, and records for these are up-to-date.

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.
- Eyewash and shower facilities are tested at least monthly, and records of maintenance and testing are kept.

Fire protection

- Sources of ignition are eliminated or controlled where flammable materials are handled or stored.
- Fire extinguishers are readily available, and their maintenance is up-to-date.
- Fire exits are unobstructed and are clearly marked.
- Workers have been trained in the use of fire extinguishers and in 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.
- A fire safety plan is in place.

Waste disposal

- Incompatible and hazardous wastes are properly segregated in clearly marked containers affixed with workplace labels.
- Cleaning and maintenance staff understand 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 equivalent are available for wastes containing controlled products.
- Disposal of solvents meets all municipal, provincial, and federal regulations.
- Sharp objects are disposed of separately from other laboratory wastes, in leakproof, 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 MSDS, hazardous waste profile sheet, or 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.
- Maintenance and cleaning staff who 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 (Other) suggested Disposal Methods for Chemicals located in Science Labs, Science Lab Classrooms and Chemical Storage rooms. By no means is this an exhaustive list. There are many ways and means of disposing of used chemicals depending on type, amount, use, location and local standards.

NOTE: Before developing any chemical disposal method ensure all relevant local, provincial and federal guidelines are followed at all times.

DISPOSAL METHODS

Classroom Management

- Make disposal options a part of all laboratory instructions for students.
- For each chemical waste produced, instruct students as to the appropriate disposal, including 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.
- Some chemical wastes 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 at least above pH 3 and below pH 8 before being placed in a sanitary drain.
- If in doubt about the proper disposal of a chemical, check with the local safety officer or refer to the Flinn system or a 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 U.S. Department of Transportation to a landfill designated by EPA 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 Suggested Methods of Chemical Disposal are some of the most quotes in North America.

First and foremost is to device a plan for Disposal based on a full inventory, types of chemicals to be disposed of, amounts and regulated practices.

Much of this information is usually provided by the supplier or on the accompanying MSDS sheets.

Below is a good starting point in regards to developing and implementing your own Chemical control and disposal system.

Option A – Contact your local Worksafe, (WCB), Environmental Organization, Local, Provincial or Federal authorities. They may be able to make suggestions or advise you about existing programs already operating.
Option B – If your school is located in an area near a college or university, that institution's chemistry department may be able to advise you about the disposal methods they employ. You will want to prepare a complete list of the substances you consider excess. There is a chance the college may be able to use some of these materials.
Option C – Have you shared your list of excess materials with other schools in your system or other neighbouring schools.
Option D – 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 teacher's groups. Other teachers have faced problems similar to yours. Bring their experience to bear on solving your problem.
Option F – In many metropolitan areas, there are local sections of the American Chemical Society (ACS). Any area with a lot of chemical industry is likely to have a local ACS section. Contact these professionals. 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 his and split the cost? This is an option many teachers have found very useful.
Option I – Do the disposal work yourself. If you elect this option, you will want to examine the disposal methods provided in the Flinn Scientific Catalog/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 time to examine your options.

If you have elected to use the disposal methods published in the Flinn Scientific Catalog / Reference Manual, there are some further considerations that need your attention. Those considerations are:

1. Have you checked with regulatory officials in your area regarding these procedures? Do not—we repeat—do not use these procedures if local regulatory officials have not approved.
2. You will need to make a list of the safety aids needed 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. Call us; we will be glad to help: 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 analysis may cause you to go back and examine disposal option G, i.e., pay a commercial firm to remove the chemicals.
6. Always practice your intended disposal activity on a tiny (micro) sample of the targeted substance before moving on to handle the larger (macro) volume. A reaction that liberates enormous amounts of heat may require that your reaction vessel be immersed in an ice bath to better control the reaction temperature. You will only make these discoveries if you "practice" with a very small sample before proceeding.
7. All of these procedures are best done in a very well ventilated laboratory and preferably in a good, efficient fume hood. If you elect to perform a procedure out of doors, 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. Have all materials at hand and immediately available.

Summary — Chemical removal and disposal are serious undertakings. Examine your options carefully and responsibly.