Chapter 3
Facility Design and Safety Equipment

OVERVIEW

As the previous chapters have shown, many laws and regulations govern safety in science classes. Some of these relate to how we do things: the plans we put in place and the procedures we use. Others relate to the physical environment: the design of the facility and the safety supplies kept in that facility. This chapter outlines guidelines and rules surrounding facility design and safety equipment.

ASSESSING THE SUITABILITY OF FACILITIES FOR SCIENCE

The selection and planning of science activities must take into account the strengths and limitations of available facilities. Although some introductory activities do not impose any facility requirements, many others—particularly at the secondary level—require some minimal facility characteristics; e.g., flat-topped surfaces are needed for activities with containers of liquids. For some activities, the use of purpose-built laboratory facilities is a practical necessity.

When deciding whether a given facility is adequate to the needs, consider the following factors:

- Does the facility have flat topped surfaces? How much flat top surface will the class need?
- Does the facility have sinks? How many will the class need? Is the number sufficient for clean-up and emergency flushing?
- How many students are in the class, and how much space does the activity require? Keep in mind that overcrowding increases risks.
- How is the facility configured? Does it allow the teacher to see all the students? Does it provide easy passage from one area to another without risk of bumping into one another?
- Does the facility have appropriate emergency response equipment; e.g., an eyewash fountain, a shower, a fire extinguisher?
- Does the facility have sufficient storage and/or adjacent preparation areas that minimize the need to transport equipment and supplies through the school? Are the storage and preparation areas lockable?
- Does the facility have adequate ventilation?
- Does the facility have a functioning fume hood that can be used in teacher demonstrations?

In planning for science activities, teachers should also be aware of any local standards that may have been established. For example, in some cases a school or district may determine the maximum number of students for a given facility and/or the number of students under the guidance of one teacher in that facility.

FACILITY CHECKLIST

The following checklist is adapted from *Science and Safety, Making the Connection* (Council of State Science Supervisors, 2002). This is not an exhaustive checklist and is only intended to address the needs of science laboratories for grades 7 to 12.

Layout and Space

- ❒ The room has adequate space. See page 12 of Chapter 1 for specific details of the Building Code requirements.
- ❒ Aisle width is adequate to accommodate equipment and students with physical disabilities (1.2 to 1.5 metres).
- ❒ Workspace per student is adequate (1.5 to 2.0 metres width of workspace per student, depending on the activity).
- ❒ The teacher can 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

- A telephone or intercom is available in case of emergencies.
- Fire detectors and heat detectors are installed in laboratories, science preparation rooms, chemical storage areas, waste disposal areas, and any other high-risk areas.
- At least one emergency eyewash station must be located in areas where corrosive chemicals are used, according to Occupational Health and Safety regulations for workers. Currently, there is no Canadian standard for the design or placement of emergency eyewash stations, therefore, those of the American National Standards Institute (ANSI) are used as a guide.

An emergency eyewash station is defined as one that provides a continuous flushing fluid to both eyes at a minimum of 1.5 L per minute for 15 minutes. It can be plumbed in or portable. Portable bottles (squeeze bottles) do not meet this standard. Squeeze bottles, however, are also to be made available for all activities where there is risk of materials entering the eye.

See the Safety Equipment and Supplies section in this chapter for information on maintenance of eyewash stations.

Exits

- The room has two exits, both with doors that open outward and have reinforced glass viewing windows or peepholes.
- Doors open easily and do not require a key to exit.
- Doorway widths are sufficient to accommodate students with physical disabilities, allow movement of equipment carts and serve as emergency exits.

Construction Materials

- ❒ Ceilings are constructed out of a material with a low flame-spread rating; e.g., drywall.
- ❒ Floors are 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).
- ❒ Laboratory bench surfaces are made of material resistant to acids, alkalis, solvents and temperate heat.

Ventilation

- ❒ Air in the room is 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.
- ❒ The exhaust ventilation system is separate from that of the chemical fume hood.
- ❒ 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, although not required by the Alberta Building Code, is 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. For more details on fume hoods, see the Safety Equipment and Supplies section that appears later in this chapter.

Electrical

- ❒ There are sufficient electrical outlets (i.e., located at intervals of 2 to 2.5 metres) to make extension cords unnecessary, and all power outlets meet *Alberta Building Code*, 1997 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.
- ❒ Outlets within 1.5 metres of water are equipped with Ground-Fault Interrupters.
- ❒ Fume hood controls are located outside the fume hood in an immediately accessible area.

Plumbing

- ❒ Plumbing is free of leaks or cracks, and drains are made of chemical resistant material.
- ❒ Counter tops are lipped toward the sink.
- ❒ 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

- ❒ Chemical storage area is 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. See Chapter 8 for more specific guidelines.
- ❒ Adequate area for the long-term storage of laboratory equipment and supplies and safety equipment.
- ❒ Preparation area, including bench space, sink and fume hood for making solutions and other materials for class use. It should also allow for storage of MSDSs, WHMIS and TDG information.
- ❒ Area for temporary storage of materials for later use, left-over materials from laboratory activities, and chemical waste storage for year-end disposal.
- ❒ Adequate refrigeration is available for storing fresh tissue/organs, enzymes, specific chemicals, agar plates and perishables.

Other Resources

Additional equipment, as indicated below, may in some situations help ensure that safe and efficient procedures are followed.

- ❒ Computer to track school equipment and chemical inventories and to access Internet information; e.g., regulations, MSDSs.
- ❒ Microwave to prepare materials such as gelatin and agar.
- ❒ Dishwasher to clean equipment, reducing the risk of injuries from broken glass and chemical exposure.

SAFETY EQUIPMENT AND SUPPLIES

Having the proper safety equipment and supplies in place in science areas of a school is critical to managing risks and dealing with emergencies that may arise. This section discusses essential safety equipment and some basic procedures for using these resources.

General Safety Equipment for Science Classrooms

With the exception of the fire blanket, this list identifies general safety equipment that is either essential or highly recommended in the science area of the school. Safety can be further enhanced by making sure teachers, students and technicians are familiar with the location and use of this equipment, that the equipment is easily accessible, and that safety posters are displayed.

Equipment	Comments
ABC-type dry chemical fire extinguisher	A 2.5 kg to 5 kg (5 lb to 10 lb) type 2, ABC extinguisher is recommended by the *Alberta Fire Code*, 1997 for laboratories. A type 4, ABC extinguisher is recommended for chemical storage areas. Note that the number in the extinguisher type refers to its volume capacity and the letters identify the class of fire(s) that can be put out. Refer to the Fire Extinguishers section discussed later in this chapter for Fire Code specifications on location of extinguishers. After use, the extinguisher will require service. Demonstrations should not be done with this extinguisher; a spare extinguisher may be reserved for that purpose.
First aid kit	One kit per room is recommended but is not mandatory according to the *Occupational Health and Safety Code*. Refer to the First Aid Kits section in this chapter.

Equipment	Comments
Eyewash station, emergency and personal (squeeze bottle)	Eyewash stations should meet Canadian Standards of Safety (CSA) and American National Standards Institution (ANSI) specifications. An emergency eyewash station is required in areas where corrosive chemicals are used. See the Facility Checklist section in this chapter for more detail. Ideally, the water supply should be tempered by mixing hot and cold water, and once activated should run hands free. All emergency eyewash stations, whether fixed or portable, require routine maintenance to ensure proper functioning and cleanliness. This requires that they be tested regularly to verify that they are operating properly. Such testing also prevents growth of microbes in stagnant residual water, and flushes out any dirt, rust or pipe scale that may be present. In areas with hard water, keeping a plumbed-in system operable is a major challenge. Two options that should be investigated to reduce rapid and frequent corrosion of the system is the use of a water softener or the attachment of the system to its own supply of distilled or buffered water, which can be replenished as required. In some situations, the most practical solution here may be to purchase a portable emergency eyewash unit with its own water supply. Where portable eyewash squeeze bottles are provided, the bottles are filled with buffered solution supplied by the manufacturer and changed regularly as per manufacturer's instructions. Also available for purchase is a buffered saline solution preserved with a suitable antibacterial agent. The antibacterial agent prolongs the shelf life of the bottle contents and the buffered saline solution is less irritating to the eyes than water out of the tap.
Simple/hand washing facilities	Hand washing facilities should be available in or near each science classroom.
Emergency shower (if chemicals are used)	 If large amounts of caustic or flammable stock are used, a deluge shower is required as specified on the chemical's MSDS. If diluted caustics or small amounts of flammable stock are used, a hand-held, telephone-style shower is sufficient.

Equipment	Comments
Fume hood (if chemicals are used)	One is strongly recommended for science preparation rooms in junior and senior high schools. The inclusion of a fume hood in high school chemistry laboratories is also recommended. In junior high, science programs and textbook resources do not call for chemicals requiring use of a fume hood. Fume hoods should meet ANSI specifications and should be inspected at least once a year by a qualified person. Fume hoods are invaluable when dispensing volatile liquids, and more toxic powdered chemicals to minimize inhalation of fumes and air-borne powder. In senior high school chemistry, they also become useful in performing reactions that generate toxic fumes.
Ultraviolet goggle sterilizing cabinet	A sterilizing cabinet is recommended in junior and senior high schools (one cabinet can serve several classrooms). The cabinet should have interlocking doors. A cabinet is not needed if each student has his or her own goggles or if other methods of sterilization, e.g., disinfectant solution, are used.
Discretionary ★Fire blankets (Not a Fire Code requirement)	★ Fire blankets are not recommended by all fire inspectors and require proper usage to avoid further damage to burned skin. Check with your local Fire Marshal for more details. Blankets containing asbestos should be removed from the school.

Personal Protective Equipment

The following list identifies personal protective equipment that should be present in every classroom that is used as a science laboratory. If injuries to students result from the failure to have or use personal protective equipment, negligence may be claimed. Appropriate safety equipment should be identified by the teacher for use during each laboratory activity as part of a routine with students prior to doing the laboratory activity. Refer to Student Safety Training in Chapter 4 for more information on use of personal protective equipment.

Equipment	Comments
Protective goggles or plastic face shields (one per student and teacher) 	Eye protection should be CSA approved and should be worn whenever there is the risk of eye injury. Goggles should be designed to completely enclose the eye area; fitted side-shields are one such option. If glasses are normally worn, goggles should fit over them. Protective equipment should be splash proof if used for chemistry. At the time of writing, goggles that completely enclose the eyes are only available through Northwest Scientific Supply, Victoria, BC. Some facility or procedure for sterilizing goggles after use is strongly recommended if goggles are shared.

Equipment	Comments
Laboratory coats or aprons	Laboratory coats and aprons should be made of approved material only, and should be worn when working with chemicals and when appropriate in other science activities; e.g., biology. Coats are preferable to aprons.
Sleeve protectors	Sleeve protectors should be worn when required.
Nonlatex disposable gloves (neoprene, nitrile or tactylon)	Gloves should be worn when handling hazardous chemicals and in biological experiments. Gloves should be used in combination with other measures because gloves may only slow down transmission of some materials, not completely prevent it. Note that some students and staff may have latex allergies.
Heat resistant gloves	Gloves should be made of treated texture silica or woven fabric. Do not use asbestos gloves.
One pair of beaker tongs 	Use tongs with heat resistant gloves when handling very hot equipment.
UV filtering glasses	Eye protection should be worn when UV sources are in use; e.g., discharge tubes, mercury or ion arcs, lamps for fluorescent 'black light' experiments. Appropriate glasses include Shields sunglasses or any glasses labelled "Blocks 99% or 100% of UV rays," "UV absorption up to 400 mm," "Special Purpose," "BS" or "Meets ANSI UV requirements."

Fire Extinguishers

The Alberta Fire Code indicates that the number and location of fire extinguishers should be governed by factors such as floor space, hazard levels and the physical design of the building. The Fire Code requires that a fire extinguisher be located in strategic sites along corridors. It also requires that a fire extinguisher be placed in either the chemical storage room or just outside this room, and recommends one in both locations, given the increased hazard level in the area. Although not compulsory by code, placement of a fire extinguisher in every laboratory is recommended.

In general, the initial selection and placement of fire extinguishers in schools is determined by design engineers prior to construction of a school. This is done in accordance with the Fire Code as well as the National Fire Protection Association (NFPA10) regulations. Schools contemplating renovations, placing additional extinguishers, or changing placement of existing units can contact the following office for more information: Alberta Municipal Affairs, Safety Services Branch, Office of the Administrator, Building and Fire Safety, Telephone: 1–866–421–6929.

The following chart shows fire extinguisher types that may be appropriate for use in schools (the type will be identified on an inspection label on the unit). ABC extinguishers are recommended (a Fire Code recommendation) for all school locations because they avoid the need to classify the fire and select the appropriate extinguisher, and because only one operational procedure must be learned and remembered.

Type	Extinguishing agent	Use
Class A	Water	Fires involving ordinary combustible materials such as wood, cloths or paper.
Class B	Dry chemical foam, carbon dioxide	Fires involving flammable liquids such as solvents, grease, gasoline or oil, and fires involving ordinary combustible materials.
Class C	Dry chemical and carbon dioxide	Fires involving electrical equipment.
Class D	Special dry powder medium or dry sand.	Fires involving combustible metals, magnesium, sodium, lithium or powdered zinc.
Class ABC	Dry chemical	All materials and fire types.

Schools can maximize the value of fire extinguishers by:

- placing extinguishers near an escape route, not in a 'dead end' location
- ensuring all teachers and support staff working in the science area know the location of all fire extinguishers, and understand when and how to use the kinds of fire extinguishers installed on site
- having fire extinguishers inspected once a year by the local fire department or an approved agency, with inspection records kept by the principal or district administrator.

First Aid Kits

First aid kits are required by schools under the *Occupational Health and Safety Code*. The contents of first aid kits are standardized and referred to by the number "1", "2" or "3." Schools occupied by 100 persons or more are required to have a number 3 first aid kit on hand at a central location that is designated as an access point for first aid services. In addition to maintaining a number 3 first aid kit in one central location, schools will normally maintain additional kits at or near facilities where activities may pose particular risks. To meet the needs of science laboratories, the recommended approach is to stock a number 1 kit in each laboratory or at a location readily accessible to several laboratories.

For further information on code requirements and guidelines, see Part 11 of the *Occupational Health and Safety Guide* at http://www3.gov.ab.ca/hre/whs/publiscation/pdf/ohs. Also see the *Occupational Health and Safety Code Explanation Guide,* part 11-6 at http://www3.gov.ab.ca/hre/whs/law/pdf/ohsc_p11.pdf. Note that the guide designates schools as "medium" hazard sites.

Kits are available from St. John Ambulance, Canadian Red Cross and most science supply companies. Number 1 kits are available as fanny packs that are suitable for use on field trips.

For field trips, the *Occupational Health and Safety Code* specifies a number 1 first aid kit (fanny pack) along with one certified first aider. The first aider does not necessarily have to be a field trip supervisor, but can be a trained employee at the field trip site. However, as part of their safety policy, school districts may require that a risk assessment be done prior to the field trip to determine what first aid equipment should be taken and what number of first aiders should go along if there are increased levels of risk.

The contents of first aid kits should be checked and replenished regularly. The kit container should be clearly marked and readily accessible, and should keep the contents dry and dust free.

The contents of a level 1 kit include:

10	antiseptic cleansing towelettes, individually packaged
25	sterile adhesive dressings, individually packaged
10	10 × 10 cm sterile gauze pads, individually packaged
2	10 cm × 10 cm sterile compress dressings, with ties, individually packaged
2	15 cm × 15 cm sterile compress dressings, with ties, individually packaged
2	7.5 cm conform gauze bandages
1	7.5 cm crepe tension bandage
3	cotton triangular bandages, minimum length of base 1.25 m
1	2.5 cm × 4.5 m adhesive tape

(continued)

5	safety pins, assorted sizes
1	pair of scissors
1	pair of tweezers
1	artificial resuscitation barrier device with a one-way valve
4	pairs of disposable latex or surgical gloves
1	first aid instruction manual (condensed)
1	inventory of kit
1	waterproof waste bag

Equipment for Clean-up and Disposal of Chemical Spills

The following list identifies items to keep in the laboratory in a clearly identified and accessible location for clean-up and disposal of spills. See Chapter 7 for clean-up and disposal procedures for different kinds of chemical spills.

Items	Comments
Acid, base and solvent spill kits	Spill kits are used for absorbing spills or diluting solutions of chemicals. Use these kits for clean-up of small spills (follow manufacturer's instructions).
Hazorb spill control pillows	These pillows are available from Lab Safety Supply Inc. Pillows are used to absorb spilled liquids (follow manufacturer's instructions).
Several litres asbestos-free vermiculite, bentonite or diatomaceous earth in container with scoop	These materials can be used for spills of solid chemicals, especially powders, and viscous or sticky liquids. Containers should be clearly labelled and contents disposed of safely.
Containers suitable for waste chemicals and solvents	Each chemical must be collected separately and labelled according to WHMIS specifications. Waste solvents should be collected only in a safety disposal can with an automatic pressure release closure.
Waste container for glass and sharp objects	A separate container for these items reduces the chance of injury to maintenance and janitorial staff responsible for normal garbage disposal.

Items	Comments
Large container of dry $NaHCO_3$ (baking soda)	Baking soda can be used to neutralize strong acids before disposal.
Plastic dustpan and brush	Use the dustpan and brush for sweeping up used sand, vermiculite or broken glass. Wash and dry both thoroughly after use.
45-cm long chemically-resistant rubber gloves	Gloves should be worn whenever dealing with spills, especially when broken glass is involved. Gloves are usually included with spill kits.
Heavy-duty garbage bags	For disposal of all solid waste, including used sand, vermiculite and contaminated broken glass. Dispose of each spill separately. Tie bags very securely, double bag if necessary and label for disposal.
Biohazard bags or extra thick garbage bags	For disposal of biological specimens and cultures.
Respirator	For pickup of certain spilled chemicals, as noted on MSDS sheets. Schools offering Science programs at grades 9 to 12 should have at least one respirator per preparation room or department.

Generic Spill Kit

A generic spill-kit mixture can be made simply by mixing equal volumes of sodium carbonate, bentonite (clay cat litter), and dry sand in a plastic container with a lid. Shake the container until the components are mixed. The contents can be mixed again just prior to use when cleaning up a chemical spill. This mixture is effective in the clean-up of the majority of spills. See Chapter 7, Managing the Release or Spill of Toxic or Corrosive Substances for more information on use.

MONITORING AND ASSESSMENT

Ongoing monitoring and assessment are important steps in maintaining and improving the condition of science facilities, equipment and materials. Regular performance of these activities supports a proactive approach to repairs and maintenance, which in turn reduces risks for accidents. Monitoring and assessment activities can take place through periodic inventory of equipment and materials, and the completion of laboratory checklists such as the one provided in Appendix D.