III. Safety Concerns and Emergency Laboratory Equipment

Making the Laboratory a Safe Learning Environment

Students need to do science, not just read about science. As an outcome of inquiry-based learning, students will recognize that science is more than a body of knowledge. It is also a way of thinking and a way of investigating. Investigation requires the use of a laboratory environment. Class size, facility design, safety equipment, and fire prevention all must be considered when establishing a safe laboratory environment.

A. Class Size

Many accidents in the science laboratory can be traced to overcrowding. The correlation between increased class size with increased accident rate has been documented. With more students moving about carrying reagents and equipment, the risk of an accident increases while direct supervision by the teacher becomes more difficult. A teacher who believes that the laboratory is unsafe due to overcrowding should communicate those concerns in writing to the department chairperson, principal, and science supervisor. Teachers and administrators should be aware of national and state recommendations regarding class size in science and work collaboratively to create a safe laboratory environment.

SAFE SCHOOL LABORATORIES HAVE . . .

- **adequate work space for students and teachers.**
- **clearly marked emergency evacuation routes.**
- **master gas and electric cut-offs.**
- **properly maintained safety equipment.**
- **signs and labels to identify safety equipment.**

1. **Recommendations of Science Organizations**

   a. Major science education organizations offer the following recommendations:

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   The National Science Teachers Association (NSTA), National Association of Biology Teachers (NABT), and National Science Education Leadership Association (NSELA) are in agreement that the maximum number of students a single teacher can supervise properly in a science classroom is 24. The Association for Science Education calls for a maximum class size of 20 for students aged 5-16 and a maximum of 14 students over 16 years of age.

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   These recommendations are supported by studies reported in *Third Sourcebook for Science Supervisors*, NSTA, 1988, stating that science classes should be at 24 students per class with a maximum of 30. One study cited in that publication concludes that a safe science class size contains no more than 22 students. In 1990, the National Science Teachers Association adopted a position statement on laboratory science that stated the number of students assigned to a science class should not exceed 24.

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b. *The Third Sourcebook for Science Supervisors*, NSTA, 1988, also states that the accident potential for a science class increases when the number of square feet per student falls below 41.

c. *Pathways to the Science Standards – High School*, NSTA, 1996, recommends 45 square feet per student for a combination science laboratory/classroom. Because effective science instruction integrates seatwork with laboratory experiences, it is important to maintain approximately 40 to 50 square feet per student in the science classroom.

d. The Maryland Science Supervisors Association position statement *Class Size Recommendations for Safe and Effective Science Education*, 1999, expresses support and agreement with the recommendations of NSTA, NABT and NSELA.

2. **State Criteria**

Many states have instituted specific criteria for the number of students and/or the allocation of space per student in a science classroom.

a. **Space Allocations.** State space allocations per student in science classrooms:

(1) *Vermont:* state code calls for 50 square feet/student.

(2) *California:* State Administrative Code requires 54 square feet/student.

(3) *Maryland*: The State Department of Education recommends 45 square feet/student (*Science Facility Design Guidelines*, 1994).


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b. **Students Per Classroom.** Many states have established recommendations on the maximum number of students in each science classroom:

(1) Five states recommend a maximum of 24 students per science classroom – Florida, New Hampshire, Oklahoma, Texas, and Wisconsin.

(2) Two states recommend a maximum of 28 students per science classroom – Georgia and Maryland.

(3) One state recommends a maximum of 15 students per laboratory – Iowa.

(4) One state recommends a maximum of 20 students per classroom – Wyoming.

(5) One state recommends no more than two students per laboratory station – Minnesota (1989 science laboratory safety law).

3. **Professional Safety Organizations**

a. A 1992 survey of state laws and guidelines on science class size found the following:

(1) One state had enforceable legislation regarding laboratory class size – Florida.

(2) 20 states have guidelines that either set a maximum class size of 25 or fewer or base student limits on the size of the classroom.

(3) Class size is part of the negotiated contract in several states.

(Marilyn Steele, Paul Conroy, and James Kaufman, "There's No Safety in Numbers - Class Size and High School Laboratory Safety - A survey of State Legislation and Guidelines for Action at Local Levels," 1992, The Laboratory Safety Workshop, 192 Worcester Road, Natick, Mass 01760)

b. Building Officials and Code Administrators (BOCA) International specifies a maximum occupancy load of 50 square feet per student in a science laboratory (May 24, 1999, interpretation of Section 1008.1.2 of BOCA National Building Code, 1996).

c. The National Fire Prevention Association (NFPA) also specifies a maximum occupancy load of 50 square feet per student in a science laboratory (Section 10-1.7.1 of NAPA Life Safety Code, 1997).

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These regulations and recommendations from professional organizations identify clear limits on space allocation and the numbers of students per classroom. Adherence to the above guidelines allows for a safe learning environment for students and teachers in science laboratories while facilitating effective, "hands-on" science activities.

B. Facilities

1. Emergency Evacuation Route

Emergency evacuation routes should be established for each classroom, and students instructed in evacuation plans. The plans should be a part of the chemical hygiene plan.

2. Master Gas and Electric Cut-offs

a. Master gas and electric cut-offs should be readily accessible, preferably outside the classroom.

b. In the event of a fire or electrical accident, shut off the gas and electricity in the laboratory.

3. Emergency Communication

Classroom teachers should be able to use a telephone or intercom to contact administrators or the school nurse in the event of an emergency.

4. Signs and Labels

The following types of signs and labels should be posted in prominent areas of the laboratory and adjoining rooms:

a. Emergency telephone numbers

b. Laboratory safety rules

c. In chemical storerooms, the National Fire Protection Association (NFPA) diamond with the highest hazard ratings of the materials in the rooms

▸*See* Appendix E, NFPA Identification Codes.

d. Labels indicating types of hazardous contents of cabinets

e. *NO FOOD* labels on refrigerators

f. Clearly label foodstuffs intended for laboratory exercises: *NOT FOR HUMAN CONSUMPTION*.

g. Location signs for:

- Fire extinguishers
- Fire blankets
- Eyewash station
- Safety shower
- Spill kits
- Goggle cabinet
- Exits
- Waste containers (e.g., chemical, broken glass)
- Master gas and electric cutoff

5.. **Teaching Students with Disabilities**

Science laboratories, like other school facilities, should be accessible and safe for students with disabilities. The American Chemical Society manual, "Teaching Chemistry to Students with Disabilities," is a good guide to ensuring that students with disabilities receive the appropriate laboratory experience.


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C. Fire Safety and Fire Control

In the event of a fire you must decide if you can fight the fire or need to evacuate the building and call the fire department. The decision whether or not to fight a fire will depend on many things, including the size and location of the fire, your confidence in dealing with the situation, and your training in fire fighting. Remember that the personal safety of the building's occupants must always be the first priority.

1. **Extinguishing Fires**

a. **Small Fires**

(1) If a person's clothing or hair catches on fire, have the person stop, drop, and roll on the floor to suffocate the flame. Do not use fire extinguishers on people.

(2) In the case of a small fire that can be easily extinguished, the teacher must take prompt action to either treat as a "serious" fire and evacuate the classroom or extinguish the fire using classroom fire management equipment.

(3) A fire in a small vessel can usually be extinguished by covering the vessel with a nonflammable material such as a fire blanket. Remove nearby flammable liquids to avoid the spread of the fire.

b. **Serious Fires**

In the event of a serious fire, follow these steps:

(1) Evacuate everyone from the room.

(2) Sound the fire alarm and notify the school administration.

(3) Shut off master gas and electrical power, if possible.

(4) Close windows and doors, if possible.

(5) Fire fighters should be informed of the potential added hazards of reagents or other materials present in the classroom or laboratory. A current inventory of hazardous materials should be available outside the work area. Posting the National Fire Protection Association (NFPA) diamond, providing emergency information about the room's contents, is the best way to give fire fighters the information they need as they enter the area.


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c. **Exceptions**

In certain circumstances where a fire may be extinguished through quick and skillful action, a teacher or other school staff *trained in the use of a fire extinguisher* may attempt to put out a fire before it spreads to a larger area. Such action must be taken from a position that allows for quick escape. It is important to understand that even small fires cannot always be extinguished easily.

2. **Fire Extinguishers and Their Use**

Class	To Fight Fires Involving:	Method to Extinguish
A	wood, paper, cloth	Use water or dry chemical extinguisher.
B	gasoline, alcohol, paint oil, or other flammable liquids	Smother by using carbon dioxide or dry chemical extinguisher.
C	fires in live electrical equipment	Cut off power to electrical equipment. Use multiple purpose (ABC) or carbon dioxide fire extinguisher.
D	metals (Na, K, Mg, etc.)	Scoop dry sand onto fire.

An easy way to remember which class of extinguisher to use is to think of Class A - ash *(solid), B* - boil *(liquid), and C* - charge *(electrical).*

3. **Fire Blankets**

   a. Fire blankets of flame-retardant wool are useful for smothering small fires as well as keeping accident victims warm. They may be rolled or folded and kept in wall-mounted cases.

   b. For clothing fires, fire blankets should be used with caution. The best method is the "stop, drop and roll" method.

D. Safety Equipment

1. **Eyewash Fountains**

   Eyewash fountains are essential in areas where reagent chemicals are used. Caustic chemicals can damage the eye within seconds of contact. The eyewash fountain should –

   - treat both eyes simultaneously.
   - provide a gentle flow of water for at least 15 minutes at 0.40 gallon per minute minimum (ANSI Z, 358.1-1998).


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   - be accessible within 10 seconds from the time of injury.
   - leave both hands free to hold eyelids open.
   - be accessible for all students.

   The National Safety Council recommends that all plumbed eyewashes be flushed for three minutes a week to reduce the risk of eye infections. A maintenance record should be maintained.


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   Portable eyewash squeeze bottles are not an acceptable alternative because they can treat only one eye, provide an inadequate water supply, are susceptible to contamination, and provide a good environment for growth of microorganisms.

2. **First Aid**

   a. Every school should have a safety and first aid plan.

   b. Each laboratory should have a first aid station for providing basic first aid and stabilizing students who will be transported to a medical facility. The stations should have the following:

      - A standard first aid kit stocked according to school policy and recommendations of the school nurse

- Emergency phone numbers posted in a conspicuous place: numbers for an on-call physician; emergency, fire and police services; poison control; and medical facilities

3. **Safety Shields**

Portable safety shields should be used for protection against hazards of limited severity, such as small splashes, heat, and fires. Use these shields with the knowledge that they provide no protection at the back and sides. If possible, the shield should be attached to the surface on which it is placed (perhaps by clamps).

4. **Safety Showers**


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A safety shower should be available in every laboratory. The shower is used to wash hazardous chemicals from the skin. The Emergency Eyewash and Shower Equipment Standard (ANSI. Z, 358.1-1998) requires that an emergency shower be located no more than 10 seconds in time nor greater then 100 feet in distance from the site of the emergency, and provide a minimum flow of 30 gallons per minute. Deluge showers are intended for major spills and should provide an uninterrupted flow of water until the valve is turned off. The shower should be tested and the tests recorded periodically in accordance with the school safety plan or as directed by the manufacturer.

A hand-held sprayer with a six-foot hose is a good alternative for small spills that frequently occur in the teaching laboratory. Such a sprayer should be a supplement and not a replacement for a plumbed safety shower.

5. **Sanitation of Safety Goggles**

If safety goggles are used by multiple classes, sanitize them between each class. Commercially available Ultraviolet (U-V) cabinets include those that hold up to 30 goggles and take 5-15 minutes per cycle.

A lower-cost option is to use a chemical disinfectant specifically made for disinfecting goggles. Household bleach and disinfectants can be used by diluting according to directions on the label.

6. **Spill Kits**

A spill kit should be accessible in each science classroom or laboratory. The kit might include:

- Spill control pillows (which are commercially available)
- Inert absorbents such as vermiculite, clay, sand, or kitty litter

- Neutralizing agents for acid spills such as sodium carbonate and sodium hydrogen carbonate
- Neutralizing agents for alkali spills such as sodium hydrogen sulfate and citric acid
- Large plastic scoops and other equipment such as brooms, pails, bags, and dust pans
- Appropriate personal protective equipment

E. Ventilation

1. Room ventilation

Adequate ventilation is important in any room in which reagent chemicals are used or stored. According to *Prudent Practices for the Laboratory,* the air in a science laboratory should be changed a minimum of six times per hour.


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Chemical storerooms should have ventilation adequate to keep atmospheric levels of chemicals below their hazardous limits. As with room ventilation, a minimum of six air changes per hour are recommended.

2. Fume Hoods

Fume hoods are the most important equipment used to protect teachers and students from exposure to hazardous chemicals and agents used in the laboratory.

a. **Velocity.** A face velocity of 80 fpm (the average velocity of air drawn through the face of the hood) should effectively remove fumes produced within the hood, conditional on proper placement and use.

b. **Rules for Using Fume Hoods**

(1) Do not store reagent chemicals in a fume hood.

(2) Fume hoods must be inspected for proper use. Devices are available to measure face velocity.

(3) Keep the sash at its most efficient level.

(4) Work as far inside the hood as possible, but keep your head outside the hood. A minimum working distance of 6 inches from the front of the hood is recommended.

(5) If possible, the hood should be located away from windows, doors, and areas of heavy traffic to avoid drafts.