

CONNECTICUT MIDDLE SCHOOL SCIENCE SAFETY

Prudent Practices and Regulations

Connecticut State
Department of Education

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Department of Education**

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I. Science Education SAFETY

I. SCIENCE EDUCATION SAFETY

Why is there a need for strong science safety programs in Connecticut's middle schools?

Revolutionary changes are taking place in science education as a result of several factors including:

- Renewed emphasis on hands-on laboratory science fostered by the National Science Standards and Connecticut science frameworks.
- Significant changes in student enrollments.
- Major building and renovations of school facilities.
- Need to meet challenges of Science Education for all students.
- Curriculum development and assessments resulting from No Child Left Behind legislation.
- Significant efforts to better prepare students at the middle school level for involvement in early college experience programs such as the University of Connecticut high school programs, Advanced Placement and International Baccalaureate at the high school level.
- Veteran teachers retiring and new teachers entering service.

Of utmost importance for teachers and administrators in planning and policymaking for these changes relative to facilities, curriculum/assessment, students and personnel is laboratory SAFETY!

Science teachers as licensed professionals are charged with duty or standard of care relative to their students. It is a professional expectation that science teachers will take all possible actions to help prevent an accident or safety incident from happening. In other words, what would the "reasonably prudent person" do to prevent exposure of students to laboratory hazards? The challenge and responsibility to help make the science laboratory a safer place for students is both a professional and legal expectation for the science teacher and school administration.

The purpose of this web link on safety is to provide direction, support and resources for middle school science teachers and school administrators relative to planning exciting and safe laboratory experiences for students based on prudent professional practices and legal safety standards.



II. OSHA Laboratory Standard: THE BEDROCK FOR MIDDLE SCHOOL SCIENCE SAFETY

II. OSHA LABORATORY STANDARD: THE BEDROCK FOR MIDDLE SCHOOL SCIENCE SAFETY

OSHA's "Occupational Exposure to Hazardous Chemicals in Laboratories" (29 CFR 1910.1450) or "Laboratory Standard" took effect in 1990. The standard sets the requirements for an employer (Board of Education) to assess the hazards in laboratories and write a "chemical hygiene plan" tailored to meet their needs. Included in the Laboratory Standard is the requirement for an employer-appointed chemical hygiene officer. The chemical hygiene officer is to provide technical support in developing and implementing the chemical hygiene plan. OSHA's chemical hygiene plan is the foundation for laboratory safety in Connecticut middle and high schools. Public schools in Connecticut are under the jurisdiction of Connecticut State OSHA and private schools are under the jurisdiction of federal OSHA.

The basic elements of the Laboratory Standard are included in the following outline:

Elements of a laboratory safety plan

- Standard operating procedures.
- Working definitions in reference to the Laboratory Standard.
- Criteria to determine and implement control measures to reduce employee exposure including engineering controls use of personal protective equipment and hygiene practices.
- Requirement that fume hoods and other protective equipment are functioning properly and within specific measures.
- Provisions for employee information and training relative to the laboratory standard, employer's chemical hygiene plan, chemical references and more.
- Circumstances where laboratory operation requires prior approval from the employer.
- Provisions for medical consultation and examinations.
- Hazard identification, including use of material safety data sheets (MSDSs) and labeling systems.
- Use of respirators.
- Required record keeping — record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.

(Appendixes)

- Designation of personnel responsible for implementation of chemical hygiene plan including chemical hygiene officer and if appropriate, chemical hygiene committee. The chemical hygiene officer is the employer-designated employee who is qualified by training or experience to provide technical guidance in the development and implementation of chemical hygiene plan. This person usually is a chemistry teacher, department head or laboratory technician.
- Provision for additional employee protection when working with particularly hazardous substances, for example, reproductive toxins, carcinogens. OSHA compliance officers initiate inspections by reviewing the employer's plans. They then focus on plan implementation and policing

A complete list of the Laboratory Standard can be found at the following OSHA website address:
<http://www.osha.gov/SLTC/laboratories/index.html>.

The bottom line for all public school districts and private schools in Connecticut relative to OSHA's Laboratory Standard is science laboratories are required to have a chemical hygiene plan. The plan must address hazardous chemical use (purchase, inventorying, labeling/identification, use, storage and disposal) and provide training/information for employees working in laboratories. This allows the employer to be in compliance with OSHA's Hazard Communication Standard for laboratory science employees.

OSHA technically covers employees, not students in the laboratory. However, to maintain a safe working environment for science teachers, all laboratory occupants, including students, must follow the chemical hygiene plan. Otherwise, the teacher, as an employee, could be put at risk.

Additional OSHA standards, interpretations of standards (official letters of interpretation by OSHA) and national consensus standards relative to laboratories may also apply to the middle school science laboratory. These include the following:

A. OSHA-related Laboratory Standards:

1. Section 5(a)(1) of the OSH Act, often referred to as the General Duty Clause, requires employers to “furnish to each of his employees employment and a place of employment which are free from recognized hazards that are causing or are likely to cause death or serious physical harm to his employees.”
2. Section 5(a)(2) requires employers to “comply with occupational safety and health standards promulgated under this Act.”
3. Occupational Noise Exposure Standard (29 CFR 1910.95) deals with acceptable sound/noise levels in the workplace.
4. Personal Protective Equipment Standards (29 CFR 1910.132) deals with body protective devices such as safety goggles/glasses, aprons, and gloves.
5. Respiratory Protection Standard (29 CFR 1910.134) deals with protective devices used to protect occupants from respiratory related exposures.
6. Lockout/Tagout Standard (29 CFR 1910.147 and 1910.333) deals with addressing control of dangerous and uncontrolled energy sources such as gas, water, electrical and mechanical devices.
7. Toxic and hazardous substances 29 CFR 1910 Subpart Z
 - a) 1910.1000, Air contaminants
 - b) Table Z-1, Limits for air contaminants
8. Hazard Communication Standard (29 CFR 1910.1200) deals with hazardous chemicals in the workplace.
9. Bloodborne Pathogen Standard (29 CFR 1910.1030) deals with blood related pathogens such as HIV and HbV.
10. Occupational exposure to hazardous chemicals in laboratories (29CFR 1910.1450) deals with using chemicals safely in the laboratory.
 - Appendix A, National research council recommendations concerning chemical hygiene in laboratories (Non-mandatory)
 - Appendix B, References (Non-mandatory)

B. Standard Interpretations

Standard interpretations are official responses to questions relative to OSHA safety standards. A growing number of these interpretations are relative to the laboratory standard and can be found at the following website:

http://www.osha.gov/pls/oshaweb/owasrch.search_form?p_doc_type=INTERPRETATIONS&p_toc_level=0&p_keyvalue=

C. National Consensus

National consensus are not OSHA regulations. They do represent professional/prudent practice and therefore provide guidance from the originating organizations. OSHA compliance officers often reference these practices relative to safety issues or concerns.

American National Standards Institute (ANSI)

- Z358.1. Contains provisions regarding the design, performance, installation, use and maintenance of various types of emergency equipment (showers, eyewashes, drench hoses, etc.). In addition to these provisions, some general considerations apply to all emergency equipment.

American National Standards Institute (ANSI)/ American Industrial Hygiene Association (AIHA)

- Z9.5-2003, Laboratory Ventilation. This authoritative publication is intended for use by employers, architects, occupational and environmental health and safety professionals, and others concerned with the control of exposure to airborne contaminants. The book includes new chapters on performance tests, air cleaning, preventative maintenance and work practices. It also highlights the standard's requirements and offers good practices for laboratories to follow. The book also offers referenced standards and publications, guidance on selecting laboratory stack designs, an audit form for ANSI Z9.5, and a sample table of contents for a laboratory ventilation management plan.

American Society of Heating, Refrigerating and Air-Conditioning Engineers (ASHRAE)

- 110-1995, Method of Testing the Performance of Laboratory Hoods. Specifies a quantitative test procedure for evaluation of a laboratory fume hood. A tracer gas is released at prescribed rates and positions in the hood and monitored in the breathing zone of a mannequin at the face of the hood. Based on the release rate of the tracer gas and average exposure to the mannequin, a performance rating is achieved.

National Fire Protection Association (NFPA)

- 45, Standard on Fire Protection for Laboratories Using Chemicals. Applies to laboratories in which hazardous chemicals are handled or stored.

International Code Council (ICC)

- 2003 International Codes. Links to several standards that are applicable to laboratories, particularly the International Fire Code. Topics addressed in this code include fire department access, fire hydrants, automatic sprinkler systems, fire alarm systems, hazardous materials storage and use, and fire-safety requirements for new and existing buildings and premises.



III. Important OSHA Definitions IN UNDERSTANDING LABORATORY SAFETY

III. IMPORTANT OSHA DEFINITIONS IN UNDERSTANDING LABORATORY SAFETY

For classroom science teachers to work successfully in the safety arena, they need to understand how OSHA definitions apply to the laboratory. OSHA definitions are key to developing chemical hygiene plans. They help to foster understanding of standard operating procedures. This in turn helps science teachers better plan and work toward securing and maintaining a safe work environment in the laboratory for all occupants. Working definitions include the following:

Action level means a concentration designated in 29 CFR part 1910 for a specific substance, calculated as an eight (8)-hour time-weighted average, which initiates certain required activities such as exposure monitoring and medical surveillance.

Chemical hygiene officer means an employee who the employer designates, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the chemical hygiene plan. This definition is not intended to place limitations on the position description or job classification that the designated individual shall hold within the employer's organizational structure.

Chemical hygiene plan means a written program developed and implemented by the employer that sets forth procedures, equipment, personal protective equipment and work practices that are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace.

Combustible liquid means any liquid having a flashpoint at or above 100 degrees Fahrenheit (37.8 degrees Celsius), but below 200 degrees Fahrenheit (93.3 degrees Celsius), except any mixture having components with flashpoints of 200 degrees Fahrenheit (93.3 degrees Celsius), or higher, the total volume of which make up 99 percent or more of the total volume of the mixture.

Compressed gas means:

- A. a gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi (2.8 kg/cc) at 70 degrees Fahrenheit (21.1 degrees Celsius); or
- B. a gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi (7.3 kg/cc) at 130 degrees Fahrenheit (54.4 degrees Celsius) regardless of the pressure at 70 degrees Fahrenheit (21.1 degrees Celsius); or
- C. a liquid having a vapor pressure exceeding 40 psi (2.8 kg/cc) at 100 degrees Fahrenheit (37.8 degrees Celsius) as determined by ASTM D-323-72.

Designated area means an area that may be used for work with "select carcinogens," reproductive toxins or substances that have a high degree of acute toxicity. A designated area may be the entire laboratory, an area of a laboratory or a device such as a laboratory hood.

Emergency means any occurrence such as, but not limited to, equipment failure, rupture of containers or failure of control equipment that results in an uncontrolled release of a hazardous chemical into the workplace.

Employee means an individual employed in a laboratory workplace who may be exposed to hazardous chemicals in the course of his or her assignments.

Explosive means a chemical that causes a sudden, almost instantaneous release of pressure, gas and heat when subjected to sudden shock, pressure or high temperature.

Flammable means a chemical that falls into one of the following categories:

- A. **Aerosol, flammable** means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches (45.7 cm) at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening.
- B. **Gas, flammable** means:
 1. a gas that, at ambient temperature and pressure, forms a flammable mixture with air at a concentration of 13 percent by volume or less; or
 2. a gas that, at ambient temperature and pressure, forms a range of flammable mixtures with air wider than 12 percent by volume, regardless of the lower limit.
- C. **Liquid, flammable** means any liquid having a flashpoint below 100 degrees Fahrenheit (37.8 degrees Celsius), except any mixture having components with flashpoints of 100 Fahrenheit (37.8 degrees Celsius) or higher, the total of which make up 99 percent or more of the total volume of the mixture.
- D. **Solid, flammable** means a solid, other than a blasting agent or explosive as defined in § 1910.109(a), that is liable to cause fire through friction, absorption of moisture, spontaneous chemical change, or retained heat from manufacturing or processing, or that can be ignited readily and when ignited burns so vigorously and persistently as to create a serious hazard. A chemical shall be considered to be a flammable solid if, when tested by the method described in 16 CFR 1500.44, it ignites and burns with a self-sustained flame at a rate greater than one-tenth of an inch per second along its major axis.

Flashpoint means the minimum temperature at which a liquid gives off a vapor in sufficient concentration to ignite.

Hazardous chemical means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term “health hazard” includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic systems, and agents that damage the lungs, skin, eyes or mucous membranes.

Appendixes A and B of the Hazard Communication Standard (29 CFR 1910.1200) provide further guidance in defining the scope of health hazards and determining whether a chemical is to be considered hazardous for purposes of this standard.

Laboratory means a facility where the “laboratory use of hazardous chemicals” occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis.

Laboratory scale means work with substances in which the containers used for reactions, transfers, and other handling of substances are designed to be easily and safely manipulated by one person. “Laboratory scale” excludes those workplaces whose function is to produce commercial quantities of materials.

Laboratory-type hood means a device located in a laboratory, enclosure on five sides with a movable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms.

Walk-in hoods with adjustable sashes meet the above definition if the sashes are adjusted during use so that the airflow and the exhaust of air contaminants are not compromised and employees do not work inside the enclosure during the release of airborne hazardous chemicals.

Laboratory use of hazardous chemicals means handling or use of such chemicals in which all the following conditions are met:

- A. Chemical manipulations are carried out on a "laboratory scale."
- B. Multiple chemical procedures or chemicals are used.
- C. The procedures involved are not part of a production process, nor in any way simulate a production process.
- D. "Protective laboratory practices and equipment" are available and in common use to minimize the potential for employee exposure to hazardous chemicals.

Medical consultation means a consultation that takes place between an employee and a licensed physician for the purpose of determining what medical examinations or procedures, if any, are appropriate in cases where a significant exposure to a hazardous chemical may have taken place.

Organic peroxide means an organic compound that contains the bivalent -O-O- structure and that may be considered to be a structural derivative of hydrogen peroxide where one or both of the hydrogen atoms has been replaced by an organic radical.

Oxidizer means a chemical other than a blasting agent or explosive as defined in § 1910.109(a), that initiates or promotes combustion in other materials, thereby causing fire either of itself or through the release of oxygen or other gases.

Physical hazard means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable (reactive) or water-reactive.

Protective laboratory practices and equipment means those laboratory procedures, practices and equipment accepted by laboratory health and safety experts as effective, or that the employer can show to be effective, in minimizing the potential for employee exposure to hazardous chemicals.

Reproductive toxins means chemicals that affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

Unstable (reactive) means a chemical that is the pure state, or as produced or transported, will vigorously polymerize, decompose, condense, or will become self-reactive under conditions of shocks, pressure or temperature.

Water-reactive means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard.



IV. Basics of LABORATORY SAFETY

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To control an employee's exposure to chemical and other hazards in the science laboratory, OSHA has fostered three general basics or principles for laboratory safety. These include:

- A. Engineering controls or environmental settings/considerations
- B. Administrative controls or work practices
- C. Personal protective equipment or body protective gear

By designing laboratory work using one of these basics or a combination of them, employees can keep their exposure levels well below OSHA permissible exposure limits or PELs.

To protect students and teachers from exposure to hazardous chemicals there is a hierarchy of defense. The hierarchy is as follows in implementation:

First line of defense — engineering controls (environmental settings/considerations).

Second line — administrative controls (work practice).

Third line — personal protective equipment (body protective gear).

A. Engineering Controls (Environmental Settings/Considerations)

Engineering controls are OSHA's preferred method in dealing with laboratory hazards. These controls remove or reduce exposure to a chemical or physical hazard by using or substituting engineered machinery or equipment. Examples include the following:

- Selection of a less toxic chemical.
- Alternate process to minimize interaction with hazardous chemicals.
- Use of wet methods to reduce generation of dusts or other particulates.
- Sound dampening materials for reduction of noise levels.
- General laboratory ventilation.
- Isolated exhaust such as a fume hood.

B. Administrative Controls (Work Practices)

Administrative controls or work practices involve changes in work procedures to better protect the employee. This can be achieved through written safety protocols/policies/procedures, supervisory activities and employee training/resources. Examples might include:

- Housekeeping — keeping the laboratory work area clear of clutter will reduce the possibility of an accident.
- Prohibiting general access of non-science employees to laboratories where hazards such as electricity, chemicals and heat sources are being used.

C. Personal Protective Equipment

In cases where engineering controls are not sufficient to provide exposure protection for employees, personal protective equipment must be used. Personal protective equipment includes clothing or devices worn to help protect an employee from direct exposure to a safety hazard or situation. Examples of personal protective equipment include protective clothing (aprons), hand protection (gloves), and eye protection (chemical splash goggles and safety glasses). Material Safety Data Sheets are a good resource for recommended personal protective equipment when working with hazardous chemicals.



V. General Science Laboratory SAFETY SPECIFICATIONS

V. GENERAL SCIENCE LABORATORY SAFETY SPECIFICATIONS

General science or interdisciplinary science broadly focuses on scientific research, knowledge and inquiry. It is the holistic approach to basic science literacy. In Connecticut schools, science curriculum and assessment (Connecticut Mastery Test or CMTs in Grades 5 and 8, and Connecticut Academic Performance Test or CAPT in Grades 9 and 10) work toward achieving this goal by exposing students to a myriad of science experiences and study. Hands-on, process and inquiry techniques are encouraged through laboratory and field work. To provide exciting and safe science experiences for students, the following safety specifications and prudent practices are highly recommended and in most cases required by regulatory agencies (OSHA, NFPA, ICC, etc.).

A. Environmental Settings and Considerations

1. Laboratory Footprint

The science work areas are the first line of defense for safety by design. They include the laboratory, preparation room and storeroom.

Footprint safety hints:

- a) There should be separate rooms for laboratory activities, preparation rooms and storerooms.
- b) Furniture placement in laboratories should be designed in such a way as to facilitate easy movement, fast egress, direct observation/supervision and no trip/fall hazards.
- c) Rooms should have two exits if more than 1,000 square feet (92.9 square meters).
- d) Legal occupancy loads per National Fire Protection Association (NFPA) and International Code Council (ICC) should be addressed based on 50 square feet net (4.6 square meters) per occupant in a lab or 60 square feet net (5.6 square meters) per occupant in a combination lab/lecture or lab. Contributing factors in establishing the specific load include placement of lab furniture/equipment, location of exits, physical/chemical hazards and more. Quasi-legal or academic/professional occupancy loads strongly recommend a maximum of 24 students per laboratory. This is providing the legal occupancy load is not violated.
- e) The laboratory should be handicap accessible relative to furniture, fixtures and more.

2. Fume Hood

Definition – A fume hood is an engineering control that provides local exhaust ventilation. It usually has a moveable front sash or window with safety glass. The hood is essential in exhausting hazardous gases, particulates, vapors, etc. It protects both students and teachers from inhalation exposure. Fume hood are usually limited to teacher preparations as opposed to active student use at the middle school level.

Hood safety hints:

- a) Use the hood to remove airborne chemicals, such as aerosols, dust, fumes and vapors.
- b) Hoods are not for storage. Keep them clean of chemicals, labware, etc.
- c) Place apparatus as far back to the rear of the hood for efficient air flow.
- d) Make sure only necessary materials are under the hood during an operation.
- e) Always keep the sash between the face and experiment with the sash lowered.

- f) Check the air flow before and during the operation [Face velocity of 80-120 feet per minute (24.4-36.6 meters per minute)].
- g) Hoods should be checked and certified operational one to four times a year, depending on frequency of use.
- h) Never block the air flow into or inside the hood.
- i) Do not use the hood as a waste disposal device for chemicals.

3. Laboratory Ventilation

Ventilation in a laboratory is critical for a safe and healthy operation. Little or no ventilation can allow the build up of harmful vapors, respiratory symptoms and more.

Ventilation safety hints:

- a) Occupied Lab air exchange rates should be six to 10 times an hour based on American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) handbook or greater than eight air exchanges per NFPA 45. Contact the director of your school facilities to have the air exchange rate accessed.
- b) Unoccupied lab air exchange rates, including chemical storerooms, should be four times an hour per NFPA 45.
- c) Air supplies to labs, storerooms, preparation rooms should never be recycled to any other part of the building, other labs, classrooms and offices.
- d) Only conduct experiments that the ventilation system can handle. Otherwise, use a fume hood or select an alternate experiment. The idea here is to limit occupant exposure.
- e) Preventative maintenance programs should be in place to change ventilation filters about four times a year. Filters need to be changed on a quarterly basis.

A good resource for laboratory ventilation is NFPA 45. It addresses required forced air ventilation in science laboratories, including academic labs.

4. Utility Controls

Laboratory facilities should have master shut-off devices for utilities such as electricity and gas. Water shut-off devices are usually located outside of the laboratory in a corridor.

5. Alarm Sensors

Heat sensors or smoke detectors and fire suppression system sensors are necessary for a safe laboratory, especially during unoccupied times.

6. Eyewash and Acid Shower

An eyewash and acid shower are necessary in case of a chemical exposure incident. These devices should be in locations where occupants are provided direct access. OSHA enforces the American National Standards Institute or ANSI (Z358.1-1998) standard which requires 10 second access to any eyewash/acid shower in the laboratory. Additional eyewash stations are needed if the 10-second access is not possible with one station in the laboratory. Eyewashes require exposure to tepid water [60–100 degrees Fahrenheit (15.6–37.8 degrees Celsius)] for 15 minutes minimum at a prescribed flow rate of 0.40 gallon (1.5 liters) per minute minimum. Preparation rooms also require access to eyewash stations in the same room. Portable eyewash squeeze bottles should not be used. They provide an inadequate water supply and foster the growth of microorganisms.

Acid or safety showers must provide a minimum flow of 30 gallons (113.6 liters) per minute with uninterrupted flow of tepid water.

Eyewashes and showers are not required by code to have floor drains. However, it is prudent and practical to have floor drains for flushing purposes, mold prevention and electrical hazards prevention from standing water.

Eyewashes are required to be inspected (flushed for about three minutes) once a week per the manufacturer's expectations to clear out sediments, biological contaminants, etc. A written flush log is to be posted next to each eyewash containing the date of flush and person doing the task. OSHA enforces this expectation.

7. Safety Shields

In some instances such as demonstrations, safety shields may be advised, in addition to chemical splash goggles.

8. Fire suppression

Given the dangers of hazardous chemicals and chances for fire and explosion, fire suppression equipment is an NFPA requirement. Fire extinguishers should be of the A-B-C type (A – combustibles like wood, paper, B – flammables like alcohol, C – electrical)(also type D for metals such as magnesium, potassium, sodium, etc.). Science teachers should be trained annually for proper use of extinguishers. Check with the local board of education policy on employee use for fire extinguishers.

Use the following NFPA “PASS” approach when working with a first extinguisher:

P – Pull the pin

Most extinguishers use locking pin to prevent inadvertent operation. Pulling the pin unlocks the operating level to allow discharge operation.

A – Aim low

Point the extinguisher nozzle at the base of the fire.

S – Squeeze the lever

A lever below the handle or some other type of triggering device must be engaged to release the extinguishing agent.

S – Sweep from side to side

Using a sweeping motion across the base of the fire and continue discharging the extinguishing agent until the fire appears to be out. Be certain to watch the fire area; if the fire reignites, repeat the process.

Signs are to be posted to show the locations of fire extinguishers, particularly in science laboratory areas where they could be easily blocked from view. The signs should be large enough to be seen clearly from a distance. Below is an example of a fire extinguisher sign.

A Fire Extinguisher Sign



Portable extinguishers weighing more than 39.7 pounds (18 kilograms) are to be installed so that the top is not more than 3.6 feet (1.1 meters) or above the floor. Those weighing 39.6 pounds or less (18 kilograms or less) must not be more than 5 feet (1.5 meters) above the floor.

Travel distance for Class D portable fire extinguishers is not to be more than 75 feet (22.9 meters) from the hazard [29 CFR 1910.157(d)(6)].

Travel distance for Class ABC portable fire extinguishers is not to be more than 50 feet (15.2 m) or less from the hazard [29 CFR 1910.157(d)(4)].

9. Fire Blanket

Flame-retardant wool or other types of materials can be helpful in smothering small fires. Never wrap a standing person on fire in a fire blanket. This can create a “chimney effect.” Wall-mounted canisters or boxes with appropriate signage should be used.

10. Goggle Sanitizer

Ultraviolet (U-V) goggle sanitizer cabinets are available and take about 15 minutes to sanitize goggles. Goggles must be sanitized if used by more than one student. Alternatives to sanitizers include disinfectants, alcohol or dish detergent.

11. Electrical Safety Controls

All science laboratories, storerooms and preparation rooms should have ground fault circuit interrupters (GFCI) electrical receptacles to protect occupants from electrical shock. This is supported by OSHA relative to the 6-foot (1.8 meters) water source application. However, given that water use can be any where in the laboratory (e.g. aquarium, ripple tanks, wave tanks and more), it is prudent to have the total laboratory with GFCI receptacles. One note – touching both metal prongs while plugging into wall receptacle will not protect the user.

B. Prudent Work Practices

1. Acids:

Acids are very dangerous and must be handled with extreme care. When diluting acid with water, “AAA” — ALWAYS ADD ACID TO WATER! Slowly stir and swirl the contents, being watchful of the heat produced, particularly with sulfuric acid. An alternative to diluting acids is purchasing diluted acids in lieu of concentrated acids from commercial supply houses.

2. Animal Care:

Foster proper handling, humane care and treatment of animals in the classroom and laboratory. Check board of education policies on animal care and use in instruction for the classroom.

3. Authorized Access:

Science teachers, department heads, principals and trained custodians are the only employees who should have key access to laboratories, preparation rooms and storerooms. Do not permit unauthorized persons in any science laboratories, preparation rooms or storerooms where hazards exist, e.g., electrical energy sources, hazardous chemicals and sophisticated equipment. OSHA considers science laboratories, preparation rooms and storerooms as secured areas.

4. Student Behavior:

- a) Horseplay or other inappropriate behavior in the laboratory is forbidden.
- b) Instruct students to never taste chemicals or other laboratory materials.
- c) Instruct students never to inhale fumes produced during an activity or experiment. Only use the “waft test” if necessary and under the direction of the teacher.
- d) Instruct students to perform only experiments authorized by the teacher.
- e) Remind students never to do anything in the laboratory that is not called for in the laboratory procedures.
- f) Have students follow all instructions, both written and oral.
- g) Remind students that unauthorized experiments are prohibited.
- h) Have students report any accident or injury to the teacher immediately, no matter how simple it may appear.
- i) Instruct students to never return unused chemicals to their original containers.
- j) Remind students to never remove any materials from the laboratory unless approved by the teacher.
- k) Remind students to never work in the laboratory without a teacher.

5. Chemical Spill Control:

A chemical spill cart should be available to handle small spills in the laboratory. Large spills and leaks require evacuation and the immediate contact of the local fire department’s hazmat team. All emergency numbers should be posted in each laboratory with direct means of communications with the front office by phone or intercom. Spill kits can be made in-house or secured through a commercial lab supplier.

Spill kits should include:

- a) Spill control pillows.
- b) Neutralizing agents for acid spills (sodium hydrogen carbonate).
- c) Neutralizing agents for alkali spills (sodium hydrogen sulfate).
- d) Pick up equipment such as brush, broom, pail, dust pan.
- e) Personal protective equipment.
- f) Inert absorbents such as sand or kitty litter.

6. Chemical Storage

- a) Chemical storerooms are secured areas and must be kept under lock and key with limited access to appropriate certified science staff and paraprofessionals.
- b) Shelving should be made of finished wood or other chemical resistant material with a front lip approximately 0.75 inch (1.9 centimeters) high.
- c) Chemicals should not be stored alphabetically. For example, acetic acid and acetaldehyde (acetaldehyde) could be adjacent neighbors on a shelf and are an incompatible pair.
- d) Flammable liquids should be stored in flammable liquid storage cabinets.
- e) Flammable and combustible cabinets should not be directly vented. Venting of these cabinets is not recommended or required except for odor control of malodorous materials. The openings on the bottom and top of the cabinets should be sealed with bungs supplied with the cabinet. If the cabinets are to be vented, vent from the bottom openings and makeup air from the top openings (NFPA 30, 4-3.2).
- f) Corrosive chemicals such as acids and bases should be stored in separate appropriate chemical storage cabinets.
- g) Nitric acid should be stored separately from acetic acid in a separate cabinet.
- h) Lithium, potassium and sodium metals should not be stored or used in a middle school science laboratory.
- i) All peroxide-forming chemicals (e.g., ethyl ether) should not be stored or used in a middle school science laboratory.
- j) Heavy items should be stored on lower shelves.
- k) Never store chemical containers on the floor.
- l) Chemical storage areas should be kept dry and in a temperature range of 50-80 degrees Fahrenheit.
- m) Chemical storage should be stored by a compatibility and use system, in addition to being secured behind locked doors and cabinets.
- n) Chemicals can be separated into organic and inorganic families, and then into compatible and related groups. Compatible groups can be separated by use of different shelves. Only store chemicals alphabetically within a related and compatible group.

Examples of storage groups that are related and compatible (examples are not necessarily recommended for use in middle school):

- (1) Inorganic Family
 - (a) Metals, hydrides
 - (b) Halides, sulfates, sulfites, thiosulfates, phosphates
 - (c) Nitrates (except ammonium nitrate), nitrites
 - (d) Hydroxides, oxides, silicates, carbonates, carbon
 - (e) Sulfides, selenides, phosphides

- (f) Chlorates, chlorites, hydrogen peroxide
 - (g) Borates, manganates
 - (h) Other inorganic acids (except nitric acid)
 - (i) Sulfur, phosphate
- (2) Organic Family
- (a) Acids, anhydrides, peracids
 - (b) Alcohols, glycols
 - (c) Hydrocarbons, esters, aldehydes
 - (d) Epoxy compounds
 - (e) Sulfides, nitrites
 - (f) Phenols

Note: Suggested storage groups are listed as a model only. Usage of most hazardous chemicals at the middle school level is not encouraged, e.g., lead and mercury salts, isocyanates, arsenates, cyanides, cyanates and others.

7. Chemical Use:**

The following chemicals should be considered for use in hands-on middle school science programs. However, like all chemicals, the teacher has a responsibility to know the character of each chemical or compound by reviewing and applying Material Safety Data Sheet information. Appropriate precautions, PPE, ventilation, etc., are an absolute must for safe use of all chemicals. Please note that this brief list represents the most common types. There are other chemicals that can be considered safe. MSDS need to be reviewed prior to use. Note also that all acids and bases listed are in a dilute, not concentrated form.

A. Chemicals to Use:

- Activated charcoal (carbon)
- Alka-Seltzer tablets
- Alum (several compounds containing aluminum and sulfate)
- Aluminum foil (aluminum metal)
- Ammonia water (ammonium hydroxide)
- Baking powder (sodium aluminum sulfate)
- Baking soda (sodium bicarbonate)
- Beet or cane sugar (sucrose)
- Borax (sodium borate)
- Boric Acid (boric acid)
- Calcium chloride salt (calcium chloride)
- Chalk (calcium chloride)
- Club soda (carbonic acid)
- Copper wire (copper metal)
- Corn starch
- Cottonseed oil
- Cream of Tartar (potassium bitartrate)
- Denatured alcohol (ethanol)
- Epsom Salts (magnesium sulfate)
- Flowers of Sulfur (sulfur)

- Fruit sugar (fructose)
- Grape or corn sugar (glucose)
- Glycerin (glycerol)
- Graphite (carbon)
- Hydrogen peroxide solution (hydrogen peroxide)
- Iron filings (iron metal)
- Olive oil
- Plaster of Paris (calcium sulfate)
- Rubbing alcohol (propanol 2)
- Salt (sodium chloride)
- Table salt (sodium chloride)
- Table sugar (sucrose)
- Vinegar (acetic acid)
- Vitamin C (ascorbic acid)

B. Chemicals Not to Use:

The following list represents common chemicals that may be found in middle school science labs or storerooms and should be removed due to their hazardous nature. Remember that any chemical can be considered hazardous if not used appropriately. Again, consult the MSDS for additional information.

- Ammonium dichromate – $(\text{NH}_4)_2\text{Cr}_2\text{O}_7$ (toxic byproducts)
- Benzene (carcinogen)
- Calcium carbide – CaC_2 (explosion hazard)
- Carbon tetrachloride – CCl_4 (carcinogen)
- Chloroform (carcinogen) CHCl_3
- Concentrated inorganic/mineral acids such as hydrochloric acid – HCl , nitric acid – HNO_3 sulfuric acid – H_2SO_4 (corrosive, serious burn and eye hazard)
- Copper sulfate (toxic)
- Diethyl ether (forms explosive peroxides)
- Dry ice – carbon dioxide (frostbite and blisters)
- Elemental mercury – Hg (highly toxic)
- Elemental potassium – K (forms explosive oxides)
- Elemental sodium – Na (dangerous reactions with water)
- Formaldehyde – HCHO (carcinogen)
- Hydrogen sulfide – H_2S (toxic vapors)
- Iodine – I_2 (respiratory irritant)
- Lead compounds such as lead chloride – PbCl_2 , lead nitrate – $\text{Pb}(\text{NO}_3)_2$ (one or more are potential carcinogens, toxic)
- Magnesium strips – Mg (burn hazard)
- Mercury salts such as mercuric sulfate – HgSO_4 (toxic)
- Methanol or methyl alcohol – CH_3OH (toxic)
- Mineral talc – $\text{Mg}_3\text{Si}_4\text{O}_{10}$ (can cause asbestosis)
- Picric acid – 2,4,6-trinitrophenol (explosive crystals)
- Potassium chlorate – KClO_3 (can cause violent reactions)
- Silver cyanide – AgCN (toxic)

- Sodium Hydroxide – NaOH (caustic)
- Vinyl Chloride – CH₂=CHCl (carcinogen)
- White phosphorous – P (fire hazard)

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8. Clothing/Hair:

Do not wear loose/baggy clothing or dangling jewelry. They are a safety hazard in the laboratory. Make sure long hair is tied back behind the ears.

9. Cold/Heat Protection:

When dealing with cryogenic or very hot materials, use heat-safety items such as safety tongs, mittens, aprons and rubber gloves.

10. De-energizing Equipment:

De-energize all equipment when leaving the laboratory. Examples include unplugging equipment (like microscopes), shutting off gas valves (use the master gas shutoff), and shutting off all water faucets.

11. Evacuation Drills:

Establish, provide signage and practice laboratory evacuation drills based on NFPA and OSHA regulations in case of fire or other incidents. Gas and electricity should be shut off during evacuations.

Keep all exits and safety equipment free from obstructions in any way. No materials should be stored in the corridors.

12. Eyewash/Shower:

Plumbed eyewash stations should be flushed for about three minutes a week as recommended by the National Safety Council and ANSI (Z358.1 Emergency Eyewash & Shower Equipment). A recording log of flushing activity/inspections is required on the device.

13. First Aid:

First aid kits should be available in each laboratory along with a written phone number for the school nurse's office for medical support in case of an incident. Check with the board of education's policy on employees administering first aid.

14. Food, Drink and Cosmetics:

Eating, drinking and the use of cosmetics are prohibited in areas where hazardous chemicals or biohazards are stored or in use.

15. Glassware:

Use caution when inserting and removing glass tubing from rubber stoppers. Lubricate glassware (tubing, thermometers, etc.) before attempting to insert it in a stopper. Protect your hands with towels or gloves when inserting glass tubing into, or removing it from, a rubber stopper.

Chipped, cracked or scratched glassware should never be used in the lab.

Broken Glassware: Broken glassware must be placed in a box or hard plastic container with a plastic liner. Include appropriate signage.

Always use glass drying racks to support glassware when drying.

16. Heating:

Never leave an active burner unattended. Never leave anything that is being heated or reacting unattended. Remember to turn off the burner or hot plate when not in use. Remember to give hot items time to cool down before handling. Otherwise, use protective gloves and equipment (tongs, etc.).

17. Housekeeping:

Work areas should be kept clean at all times. Students should only use laboratory instructions, worksheets and necessary equipment in the work area. Other materials such as backpacks, books, purses and jackets should be stored in the classroom area or lockers. Orderliness is required in science laboratories by the OSHA housekeeping standard.

18. Hygiene:

Personal hygiene is required before and after laboratory work by washing hands with soap and water.

19. Hazard Rating System:

Laboratories, preparation room and chemical storage areas should have the NFPA diamond with the highest hazard ratings of chemicals in the room posted.

20. Inventory – Chemicals:

Be certain to have a complete and up-to-date chemical inventory based on OSHA's HazCom Standard. The following information is suggested: names of chemical, storage location, date of purchase, and amount on hand. OSHA requires only the identity name referenced in the MSDS or common name/trade name. Hazard information is not required in the inventory because the employee can secure that information from the MSDS. The inventory should be ongoing and current at all times.

21. Labeling:

Labeling is required of all chemical containers. All labels must be legible, in English and include chemical/product name. Chemical information related to relevant hazards must also be evident. All chemicals are to have labeled containers with appropriate information, e.g., full chemical name and formula, concentration and how the chemical can harm the body.

22. Material Safety Data Sheets (MSDS):

MSDS for all hazardous chemicals must be kept in a place which is easily available to employees. For easy access during a medical emergency or safety incident, MSDS for chemicals being used on a particular day should be posted in the laboratory. As part of the laboratory safety preparation for an experiment, all appropriate MSDS's should be reviewed with students. MSDSs must be maintained by the employer for at least 30 years. Computer terminals or fax machines that allow employees to read and refer to the MSDS are permitted to be maintained at the jobsite, in lieu of paper copies, as long as no barriers to access exist.

A list of the hazardous chemicals known to be present using an identity that is referenced on the appropriate MSDS (the list may be compiled for the workplace as a whole or for individual work areas) is required. [1910.1200(e)(1)(i)]

23. Microwave Ovens:

Microwave ovens are used for life science activities such as heating water. Never use containers with lids on them in a microwave. Never place metallic objects, aluminum foil or metal pots, in a microwave. Students should be instructed on their proper use. Occupants with pacemakers should not work in the proximity of a microwave oven. Proper signage warning of microwave use should be posted outside the laboratory door.

24. Personal Protective Equipment:

Make sure appropriate personal protective equipment is used, e.g., gloves, apron, chemical splash goggles (safety glasses for projectiles, solids), closed-toe foot protection.

25. Pipette Procedure:

Use a suction bulb when filling pipettes, not mouth suction.

26. Planning for Experiments/Demos:

Perform experiments or demonstrations prior to assigning the activity to students. Provide verbal and written safety instructions to students.

27. Refrigerator

Consumable food must not be placed in the same refrigerator as chemicals or biohazard material. Refrigerators used for nonconsumable materials should be labeled "Contents Not For Human Consumption." Use appropriate signage on the doors of both types of refrigerators.

28. Safety Hazards:

Science teachers should be vigilant in doing safety inspections in the laboratory. Report any existing and potentially hazardous safety violations to the science supervisor and principal in writing. Do not conduct science activities without appropriate and functioning safety equipment.

29. Safety Rules:

Safety rules should be posted in a visible place.

30. Safety Strategies:

- a) Never leave students unsupervised in a laboratory or science classroom.
- b) Students should read and sign lab safety contracts prior to doing any laboratory activities.
- c) Safety procedures should be reviewed by the teacher with students prior to laboratory work.
- d) Take action to insure student accountability, such as testing of safety procedures.
- e) Never overlook any safety infraction. Direct teacher/student intervention supervision is essential.
- f) Document all safety planning initiatives in plan book.
- g) Instruct students in the proper use of all safety equipment.

31. Sharps:

Pins, knives, needle probes and scissors should be used with extreme care. Sharps to be discarded should be placed in a separate, rigid container labeled "SHARPS ONLY."

32. Signage:

Have the appropriate signage installed/posted for the following items: exits, eyewash station, fire blanket, fire extinguisher, goggle sanitizer, master shutoffs, safety shower, spill kits and waste containers.

33. Waste Disposal (Items to Be Recycled):

Dispose of all chemical waste properly as noted by the teacher or MSDS. Chemicals should never be mixed in sink drains. Sinks should only be used for water and those solutions noted by the instructor. Solid chemicals, filter paper, matches and all other insoluble materials are to be disposed of in the properly labeled waste containers. Cracked or broken glass should be placed in the special container for "Broken Glass."

Waste disposal or items to be recycled should be done on an annual basis. There needs to be appropriate storage and labeling.

C. Personal Protective Equipment (PPE) Requirements:

1. Eye Protective Devices

Eye protection is required by Connecticut state statute where the process used can cause damage to the eyes or where the protective device can reduce the risk to injury. For example, students in a ninth-grade science class using meter sticks for measurement gathering or launching rockets should have safety glasses with side guards at a minimum. If hazardous chemicals such as acids are being used, chemical splash goggles are required. The general guide is as follows:

Chemical Splash Goggle (indirect vents and ANSI impact standard Z87.1) when using hazardous liquids or solids.

Safety glasses (side shields and ANSI impact standard Z87.1) when using solids or projectiles.

Eye protection should be hygienically cleaned after each use via UV goggle sanitizer, alcohol wipes or detergent and warm water.

All K-12 schools in Connecticut are required to have the State Goggle Statute Section 10-21 4a-1, (including chart and precautions) posted in science laboratories. The signage must be in clear view for occupants to see.

**Regulations Concerning Eye Protective Devices
As Authorized by Section 10-21a of the Connecticut General Statutes**

The regulations of Connecticut state agencies are amended by adding sections 10-21 4a-1 to 10-21 4a-3, inclusive as follows:

Section 10-21 4a-1. By whom, when and where eye protective devices shall be worn: definitions. Any person who is working, teaching, observing, supervising, assisting in or engaging in any work, activity or study in a public or private elementary or secondary school laboratory or workshop where the process used tends to damage the eyes or where protective devices can reduce the risk of injury to the eyes concomitant with such activity shall wear an eye protective device of industrial quality in the manner in which such device was intended to be worn. For the purposes of sections 10-21 4a-1 to 10-21 4a-3, inclusive, “workshop” and “laboratory” shall include any room or area used to teach or practice industrial arts, vocational and technical education; science, arts and crafts, or any similar skill, activity or subject. The following list of sources of danger to the eyes and the type of protection required to be worn in each case is exemplary, not exclusive.

SOURCE OF DANGER TO THE EYES	TYPE OF PROTECTION REQUIRED
a) Caustic or explosive chemicals	Clear goggles, splash proof
b) Explosives, solids or gases	Clear goggles
c) Dust producing operations	Clear goggles, splash proof
d) Electric arc welding	Welding helmet
e) Oxy-acetylene welding	Colored goggles or welding helmet
f) Hot liquids and gases	Clear goggles, splash proof
g) Hot solids	Clear or colored goggles, or spectacles
h) Molten metals	Clear or colored goggles
i) Heat treatment or tempering of metals	Clear or colored goggles
j) Glare operations	Colored spectacles or goggles, or welding helmet
k) Shaping of solid materials; chipping, cutting, grinding, milling, sawing, stamping	Clear goggles or spectacles
l) Repairing or servicing of vehicles when hazard is foreseeable	Clear goggles or spectacles
m) Spraying and dusting	Clear goggles, splash proof
n) Other similar activity being conducted in the instructional program which risks damage to the eyes	Proper eye protective device

Section 10-21 4a-2. Minimum standards for the design, construction and quality of eye protective devices used in schools. Any eye protective device used in such school workshops or laboratories shall be designed and constructed to resist impact, provide protection against the particular hazard for which it is intended, fit snugly without interfering with the movements of the user and be durable, cleanable, and capable of frequent disinfection by the method prescribed for such device by the school medical adviser.

All materials used in such eye protective devices shall be mechanically strong and lightweight, non-irritating to perspiring skin and capable of withstanding washing in detergents and warm water, rinsing to remove all traces of detergent and disinfection by methods prescribed by the school medical adviser without visible deterioration or discoloration. Metals used in such devices shall be inherently corrosion resistant. Plastics so used shall be non-flammable and shall not absorb more than five percent of their weight in water.

Section 10-21 4a-3. Responsibilities of public and private elementary and secondary school governing bodies. The governing board or body of each public and private elementary and secondary school in the state shall require the use of appropriate eye protective devices in each laboratory and workshop by any person in such areas during any activity engaged in, and shall post warnings and instructions in laboratories and workshops which include the list of hazards and protection required set forth in Section 10-21 4a-1. Such boards shall make and enforce rules for the maintenance of all eye protective devices in clean, safe condition and shall replace any such protector which becomes irritating to the skin.

Purpose: To direct the school administrators in the kinds, construction, times and uses of devices for eye protection of teachers and pupils in school laboratories and workshops.

Connecticut Law Journal
January 9, 1968

2. Face Protection

Eye protection leaves the face exposed. In certain instances, additional PPE is required beyond eye protection. Face shields protect against most splashes of severely corrosive materials and flying particles. A better solution is to use a fume hood with the sash down as a face barrier.

3. Hand Protection

OSHA Hazard Communications and Laboratory Standard required PPE for hands. Gloves are designed for very specific types of situations. One type of glove does not fit all needs. The manufacturer's claims should be reviewed and followed. Gloves should only be used under the conditions for which they were designed.

Types of gloves appropriate for secondary schools include:

- a) Latex/vinyl (microorganisms and biological material – latex is a known allergen for some people and therefore should be avoided);
- b) Neoprene (solvents).

Check Material Safety Data Sheets for the appropriate type of glove for maximum protection. Glove removal is effected by peeling one off of your hand starting at the wrist, moving toward the fingers. Don't allow the surface of the exposed glove to come in contact with the skin. When one glove is removed, use it to peel off the remaining glove.

4. Foot Protection

For laboratory work, students should be wearing closed toed shoes or sneakers. No flip flops or sandals are allowed. This protects the feet from falling objects such as spilled chemicals, weights, rocks, etc.

5. Aprons

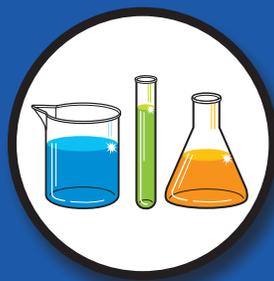
Aprons are required to protect clothing and skin from spills, splashes, etc. On absorbent type aprons are the best. Make sure they are the appropriate length – just below the knees to prevent trip/fall hazards if too long.

6. Clothing

The greatest protection is from long pants and long sleeve shirts/blouses. This again protects the skin.

RESOURCES

American Chemical Society (<http://www.acs.org>)
American National Standards Institute (<http://www.ansi.org>)
Centers for Disease Control (<http://www.cdc.gov>)
MSDS Online (<http://www.msdsonline.com>)
National Academy Press (<http://www.nap.edu>)
National Fire Protection Association (<http://www.nfpa.org>)
National Safety Council (<http://www.nsc.org>)
National Science Education Leadership Association (<http://www.nsela.org>)
National Science Teachers Association (<http://www.nsta.org>)
Occupational Health and Safety Administration (<http://www.osha.gov>)



VI. Physical Science Laboratory SAFETY SPECIFICATIONS

VI. PHYSICAL SCIENCE LABORATORY SAFETY SPECIFICATIONS

Physical science includes the sciences of earth/space science, chemistry and physics that explore the nature and characteristics of energy and nonliving matter. The boundaries between the physical and life sciences are artificial. With the advancements in science today, one field overlaps into another; e.g., biophysics, biochemistry, etc.

PHYSICS-BASED PHYSICAL SCIENCE

A. Electricity

Given the inherent dangers in the laboratory study of electricity, safeguards and safety procedures need to be in place for students and teachers. Consider the following safety specifications in working with electricity:

1. Know where the master switch is for electricity in the laboratory in case of an emergency.
2. Make students aware of the appropriate use of electricity and dangers of misuse and abuse.
3. When using batteries, always inspect them first for damage including cracks, leakage. Discard in an environmentally appropriate way if any of these conditions occur.
4. When unplugging cords, always pull cords from the plug at the electrical receptacle and never pull the cords from the wire.
5. Use only ground fault interrupt (GFI) protected circuits!
6. Remove all conductive or metallic jewelry before working with electricity.
7. Prevent trip and fall hazards by placing wires away from places where people walk.
8. For routine maintenance like changing bulbs, make sure the device is unplugged before initiating the work.
9. Never open a battery. The contents are corrosive and can be toxic or poisonous.
10. When storing batteries, never allow the terminals to touch or short circuit.
11. Be water phobic when working around electricity. Never use water or have wet hands when dealing with cords, plugs or electrical equipment. Never run a cord near or over a sink.
12. Utility pipes such as water and gas are grounded. Do not touch an electrical circuit and utility pipes at the same time.
13. Never plug damaged electrical equipment into a wall receptacle. This includes frayed wires, missing ground pin and bent plugs.
14. Never overload circuits as they will overheat and cause power outages or fires.

B. Electrostatic Generators:

Electrostatic generators such as Van de Graaff generators are a real attention getter for students in the study of electrostatics. The following prudent safety procedures are in order, however:

1. The generator should only be operated as a demonstration by the teacher.
2. Electronic circuit or devices such as cell phones, computers and cameras can be permanently damaged by the machine's sparks. Keep them at least 50 feet (15.2 meters) away.

3. Always use a surge protector inline with the generator's power cord.
4. Students with epilepsy, heart or nervous system conditions, or pacemakers should never be in the proximity of an electrostatic generator.
5. Never operate the generator near flammable or combustible materials.
6. Never leave the machine operating unattended.

C. Ionizing Radiation:

The use of ionizing radiation sources in middle school science laboratories is not advocated given the potential for unsafe exposure levels and health indication.

D. Mechanics:

The study of mechanics in physical science provides many touchstones to everyday applications for students. However, laboratory activities in this area are not without safety concerns. Students and teachers can be injured if hit by rapidly moving objects or projectiles.

Always use caution when dealing with projectiles, falling objects, moving equipment, exposed belts, powerful permanent magnets, sharps such as Exacto knives and razor blades, and springs.

Special attention should be given to the following safety procedures when working with model rockets.

Use only lightweight, nonmetal parts for the nose, body and fins of the rocket.

1. Use only commercially made model rocket engines.
2. To prevent accidental eye injury, place launchers so that the end of the launch rod is above eye level or cap the end of the rod when it is not in use.
3. Always use either safety glasses or safety goggles with an ANSI Z-87.1 rating when launching rockets.
4. Do not tamper with rocket engines or use them for any purposes except those recommended by the manufacturer.
5. Launch rockets outdoors, in an open area and in safe weather conditions with wind speeds no greater than 20 mph.
6. Use a recovery system such as a flame-resistant or fireproof streamer or parachute so that it returns safely and undamaged and can be flown again.
7. Launch rockets with an electrical launch system and electrical motor igniters.
8. The launch system should have a safety interlock in series with the launch switch, and will use a launch switch that returns to the "off" position when released.
9. Use a safe launch distance of at least 15 feet (4.6 meters) away from the launch pad for rockets with up to "D" size engines. Use 30 feet (9.1 meters) when launching larger rockets engines.
10. If the rocket misfires, remove the launcher's safety interlock or disconnect its battery. Wait 60 seconds after the last launch attempt before allowing anyone near the rocket.
11. Launch a rocket from a launch rod, tower, or rail that is pointed within 30 degrees of the vertical to ensure the rocket flies nearly straight up.

12. Use a blast deflector to prevent the engine's exhaust from hitting the ground.
13. Do not launch rockets at targets such as tall buildings, power lines or near airplanes.
14. Never put any flammable or explosive payload in a rocket.
15. Do not attempt to recover rockets from power lines, tall trees or other dangerous places.

E. Nonionizing Radiation – Lasers:

Nonionizing radiation consists of electromagnetic radiation that lacks sufficient energy to ionize matter. These may include the use of lasers, microwaves and infrared radiation in the physical science laboratory. Nonionizing radiation can cause injury if handled improperly.

It is prudent safety practice to have students and teachers wear ultraviolet-protected chemical splash goggles when working with ultraviolet light sources. Students' skin and eyes can be particularly sensitive to ultraviolet exposure. When using hand-held ultraviolet lamps for activities such as forensics or phosphoresce, use caution not to directly view the ultraviolet light source.

The most common nonionizing radiation equipment used in physical science laboratories is the laser. Safety specifications vary depending on the class of laser instrument being used. The following general safety specifications provide prudent advice and direction for use in middle school physical science courses:

1. Lasers, including handheld laser pointers, should be used only for demonstration purposes by the teacher.
2. Before operation, warn all individuals present of the potential hazard.
3. Use the laser away from areas where the uninformed and curious might be attracted by its operation.
4. In conspicuous locations inside and outside the work area and on doors giving access to the area, place hazardous warning signs indicating that a laser is in operation and may be hazardous.
5. Remove all watches and rings before changing or altering the experimental setup. Shiny jewelry can cause hazardous reflections.
6. Practice good housekeeping in the lab to ensure that no device, tool or other reflective material is left in the path of the beam.
7. Cover all exposed wiring and glass on the laser with a shield to prevent shock and contain any explosions of the laser materials. Be sure all nonenergized parts of the equipment are grounded.
8. Set up the laser so that the beam path is not at normal eye level, i.e., below 3 feet (0.9 meters) or above 6.5 feet (2 meters).
9. Use shields to prevent strong reflections and the direct beam from going beyond the area needed for the demonstration or experiments.
10. Use only lasers operating inside the visible range.
11. A key switch to lock the high voltage supply should be installed.
12. View holograms only with a diverged laser beam. Be sure the diverging lens is firmly attached to the laser.
13. Illuminate the area as brightly as possible to constrict the pupils of the observers.
14. The target of the beam should be a diffuse material capable of absorbing the beam and reflection

15. Do not at any time look into the primary beam of a laser.
16. Do not aim the laser with the eye. Direct reflection can cause eye damage.
17. Do not look at reflections of the beam. These, too, can cause retinal burns.
18. Do not use sunglasses to protect the eyes. If laser safety goggles are used, be certain they are designed for use with the laser being used.
19. Report any afterimage to a doctor, preferably an ophthalmologist who has had experience with retinal burns. Retinal damage is possible.
20. Do not leave a laser unattended.

F. Pressurized and Vacuum Systems:

Pressurized gas cylinders can explode. Bell jars can implode. Use only pressurized or evacuated items that are designed for such an activity.

Working with vacuums has the potential of an implosion and the possible hazards of flying glass, splattering chemicals and fire. Potential risks must be carefully considered. Equipment at reduced pressure can be prone to rapid pressure changes forcing liquids through an apparatus.

For safety prevention, adopt the following safety protocols when dealing with pressurized and vacuum systems:

1. Always use safety glasses or goggles with ANSI Z87.1 ratings.
2. Procedures should always be effected inside a hood.
3. Place vacuum apparatus out of harm's way so an accidental hit is minimized. Placement of transparent plastic around the apparatus helps prevent injury from flying glass in case of an explosion.
4. Protect vacuum pumps with cold traps and vent the exhaust into an exhaust hood.
5. Assemble vacuum apparatus in a manner that avoids strain, particularly to the neck of the flask.
6. Do not allow water, solvents and corrosive gases to be drawn into vacuum systems.
7. Avoid putting pressure on a vacuum line to prevent stopcocks from popping out or glass apparatus from exploding.

G. Sound:

Usually physical science laboratory equipment and activities do not normally produce noise levels requiring use of hearing protection. The OSHA Occupational Noise Standard (29 CFR 1910.95) has established a noise action level of 85 decibels (dBA) averaged over eight hours. Wind tunnels, motors, engines and other laboratory equipment used in physical science laboratories have the potential to exceed the action level. Science teachers should monitor sound levels and provide hearing protection for themselves and students. It is advised that this be applied even below the action level.

CHEMISTRY-BASED PHYSICAL SCIENCE

A. Hazardous Chemicals:

A hazardous chemical, as defined by the Hazard Communication Standard 29 CFR 1910.1200 (d), is any chemical that can cause a physical or a health hazard. This determination is made by the chemical manufacturer. Examples of chemicals causing physical hazards include combustible liquids, compressed gases, explosives, flammables and organic peroxides. Examples of chemicals causing health hazards include carcinogens, corrosives, irritants, sensitizers, toxic agents, reproductive toxins and agents that can damage the eyes, skin, lungs or mucous membranes.

B. Chemical Hazards:

1. **Flammables** – Flammable liquids and vapors are the most common fire hazard in the laboratory. Fires need the following three items:
 - a) an oxidizing atmosphere (e.g., air);
 - b) flammable gas or vapor at a concentration within the flammability limits of the substance; and
 - c) an ignition source.

The flash point of a liquid is the lowest temperature at which there are sufficient vapors to form a flammable mixture with air.

The flammable limits/range are the lower and upper vapor concentrations in air at which the vapor will burn.

2. **Carcinogens** – Any chemical that can cause cancer. Included are known or suspected carcinogens such as formaldehyde, benzene, carbon tetrachloride, nickel salts, sodium dichromate and sodium chromate. These chemicals should be removed from high school stock rooms and disposed of properly.
3. **Corrosives** – Corrosives (e.g., acids, bases, and metallic salts) are chemicals that cause visible destruction of, or irreversible alterations in, living tissue by chemical action at the site of contact. Corrosive effects may occur to the skin, eyes, respiratory tract and gastrointestinal tract. These chemicals need to be handled using utmost care and safety protocols.
4. **Explosive Substances** – Explosive substances are chemicals that decompose at an extremely rapid and violent rate producing large volumes of gas. Ammonium nitrate, isopropyl ether, picric acid and sodium azide are examples of explosives and should be removed by trained experts from the local fire department.
5. **Oxidizers** – Oxidizing agents (e.g., nitric acid, oxygen, chlorine, fluorine, hydrogen peroxide, nitrates, nitrites) are chemicals that bring about an oxidation reaction. There is risk of a fire or an explosion when strong oxidizing agents come into contact with easily oxidizable compounds, such as metals, metal hydrides or organics. Because oxidizing agents possess varying degrees of instability, they can be explosively unpredictable.
6. **Sensitizers/Irritants** – Sensitizers are chemicals that cause tissue to show an allergic response after repeated exposure, e.g., acetone and zinc chloride. Irritants cause reversible inflammation at the site of contact, e.g., acetic acid and ammonia.

7. **Solvents** – Solvents such as acetone, diethyl ether and ethanol have vapor pressures around room temperature and therefore are considered fire hazards. Precautions include storage in a flammable liquid cabinet and usage under a fume hood.
8. **Toxic Chemicals** – These are chemicals that affect life processes and can cause death, temporary incapacitation or permanent harm to humans or animals. Toxic chemicals are a danger to the body via absorption, ingestion and inhalation. The Material Safety Data Sheet (MSDS) is a good source to determine the route of entry and measure of toxicity.
9. **Water Reactives** – “Water-reactive” means a chemical that reacts with water to release a gas that is either flammable or presents a health hazard. Examples include aluminum powder, calcium carbide, magnesium powder, sodium, potassium and zinc powder.

C. Ordering Chemicals – Safety Procedures:

With the cost of shipping, storing and disposing of chemicals, planning for ordering of chemicals is critical. The following safety procedures are recommended for ordering practices:

1. Estimate the amount of chemicals needed based on inventory.
2. Order only minimal amounts of chemicals. Think “micro-chemistry”!
3. Review MSDS for all new chemicals.
4. Make sure laboratory ventilation system and/or fume hood exhaust will meet the needs for chemical use.
5. Make sure appropriate storage is available: flammable liquid cabinet, acid cabinet, chemical storeroom.

D. Receiving Chemicals:

Safety procedures for receiving shipments of chemicals and their use include the following:

1. Purchase orders should have MSDS requirements stated for all hazardous chemicals purchased.
2. Make sure chemicals are stable and secure for transporting.
3. Only transport chemicals with minimum exposure to building occupants.
4. Gas cylinders should normally not be stored or used at the middle school level science laboratory.
5. Do not accept any hazardous chemicals without an MSDS.
6. Do not accept any hazardous chemicals without proper labeling.

E. Storage of Chemicals:

1. All chemical shelving needs front edge lips of approximately 0.75-inch (1.9 centimeters) height.
2. All chemical storage areas are considered secured areas and must have locks. Only science certified personnel, administrators or trained custodians should have access. Students are not to have access to any chemical storage areas.
3. Storage areas are to have appropriate ventilation (non-re-circulating) with a minimum of four room changes per hour.
4. All chemical storage shelving and cabinets are to be secured to the wall to prevent tipping over.
5. Chemicals should not be stored above eye level.

6. Have a spill control station near the chemical storage site.
7. All chemical containers must be properly labeled, dated and in good condition in preparation for storage.
8. Chemicals are to be organized by compatibility, not alphabetically. Incompatible chemicals are to be stored separately.
9. Chemicals should be stored alphabetically within compatible groups.
10. Segregate chemicals by hazard class (e.g., flammable liquids, combustible liquids, flammable solids, corrosive acids, corrosive bases, oxidizers and water reactives).
11. Flammable liquids should be stored in National Fire Protection Association (NFPA) approved safety cans and cabinets.
12. Hazardous liquids should be stored within a secondary containment.
13. Chemicals should not be exposed to direct heat, sunlight or highly variable temperatures.
14. Never place large or heavy containers on high shelves.
15. Never store chemicals on tops of cabinets or on floors.

F. Handling and Using Chemicals:

1. Be aware of safety equipment location in case of a chemical splash or spill including the chemical spill cart.
2. Review MSDS and labels for hazards associated with a chemical before using it.
3. Do not eat or drink in the laboratory.
4. Use the buddy system. Never work alone without another staff member present.
5. Use appropriate personal protective equipment (PPE): chemical splash goggles, hand protections, apron, closed toed shoes. Flip flops and sandals are inappropriate footwear in the chemistry lab.
6. Never smell, taste or touch chemicals with bare hands.
7. Never return a chemical to original container once it has been removed.
8. Never leave hazardous chemicals or processes unattended.
9. Use good housekeeping practices. Keep areas clean and uncluttered.
10. Always clean up after completing the laboratory activity.
11. Always wash hands with soap and water after completing the laboratory activity.

G. Chemical Disposal:

1. Chemicals are to be disposed of or recycled using environmentally safe procedures.
2. Read MSDS for appropriate chemical disposal.
3. Place used chemicals or products in containers designed and labeled for that purpose.
4. Label the container with appropriate chemical information – content and volume or mass.
5. Keep container closed unless filling.
6. Contact the school's facility department for appropriate disposal instructions.
7. Use only certified and approved chemical waste contractors.

H. Chemical Labeling-National Fire Protection Association (NFPA) System:

The NFPA system of chemical labeling is characterized by a color coded diamond shaped symbol. It is designed to quickly identify safety hazards of the material and the degree of flammability, level of health and instability hazards. For a detailed explanation, see the following websites:

<http://www.webworldinc.com/wes-con/nfpasign.htm>

http://www.nmsu.edu/~safety/programs/chem_safety/hazcom_NFPA_labels.htm

I. Chemical Labeling:

Hazardous Materials Identification System HMIS Hazardous Materials Identification System (HMIS) was developed by the National Paint & Coatings Association (NPCA) in concert with OSHA's HazCom Standard. It allows employees to quickly know the type and degree of hazards associated with the chemical being used. However, it is not designed for emergency information like the NFPA system.

See <http://www.ilpi.com/msds/ref/hmis.html> and <http://www.paint.org/hmis/index.cfm>.

J. Secondary Labels:

If chemicals are transferred from a stock bottle into a smaller container, the latter is known as a secondary container. Although OSHA does not require labeling of the secondary container in all instances (e.g., one person filling a secondary container from a properly labeled primary container for one shift, one person use only operation) per the hazard communications standard, it is prudent safety practice in the laboratory to do so. A good start is placing the name of the chemical, NFPA label system information and date.

K. Material Safety Data Sheets (MSDS):

The American National Standards Institute has standardized the MSDS format, which OSHA has recognized. The following format is used:

MSDS's require 16 sections under the ANSI MSDS standard:

1. Chemical or substance identity, CAS number, synonyms, and company contact information, including emergency number.
2. OSHA hazardous ingredient composition and data on components, including exposure limits.
3. Health hazards identification, including acute and chronic levels.
4. First aid measures for exposure.
5. Firefighting measures.
6. Accidental release measures.
7. Handling and storage, including information on explosive risk, flammability, chemical incompatibility and special storage requirements.
8. Exposure controls (OSHA Permissible Exposure Limits or PELs) and personal protection equipment.
9. Physical and chemical properties such as evaporation rate, specific gravity and vapor density.
10. Stability and reactivity.
11. Acute and chronic toxicological information.
12. Ecological information.
13. Disposal considerations – these are suggestions but federal, state and local regulations must be followed.

14. Transport information relative to factors such as flammability, radioactivity and reactivity.
15. Regulations for the chemical.
16. Other information including labeling, disclaimers and references.

Exposure Limits:

Exposure limits are designed to protect employees from excessive exposure to hazardous substances. The limits usually are relative to the concentration of a chemical in the air. However, they also may define limits for physical agents such as noise, radiation and heat. There are a variety of exposure limits established by professional safety organizations (American Industrial Hygiene Association), governmental organizations (OSHA, EPA) and chemical manufacturers. The information can usually be found on MSDS.

Legal Limits:

Permissible Exposure Limits (PELs) are established by OSHA, 29 CFR 1910.1000, and 1910.1001 through 1910.1450. They specify the maximum amount or concentration of a chemical to which a worker may be exposed.

These are defined in three ways:

1. Ceiling Limit (C): the concentration that must not be exceeded at any part of the workday
2. Short-Term Exposure Limit (STEL): the maximum concentration to which workers may be exposed for a short period of time (15 minutes)
3. Time-Weighted Average (TWA): the average concentration to which workers may be exposed for a normal, 8-hour workday.

Other Exposure Limits (legally unenforceable):

1. Immediately Dangerous to Life and Health (IDLH) – These are conditions that pose an immediate danger to health and life by exposure. These were originally established for decision relative to respirator use.
2. Threshold Limit Values (TLVs) – TLVs are prepared by American Conference of governmental Industrial Hygienists volunteer scientists. They show the level of exposure that workers can experience without an unreasonable risk of disease or injury.
3. Recommended Exposure Limits (RELs) – These are recommended by the National Institute for Occupational Safety and Health. They indicate the concentration of a substance to which a worker can be exposed for up to a 10-hour workday during a 40-hour work week without adverse effects. RELs tend to be more conservative than PELs or TLVs.
4. Workplace Environmental Exposure Limits (WEELs) – Developed by American Industrial Hygiene Association volunteers. WEELs are usually developed for chemicals that are not widely used or for which little toxicity information is available
5. Company-Developed Limits – Developed by company scientists. These are usually based on only short-term studies of animals and generally intended for internal company use.

L. Chemical Tracking System:

Chemical tracking systems are a chemical database which is used to characterize the life of chemicals used in the laboratory. They should cover the history of the chemical. Remember that schools own the chemical from the cradle to the grave! There are various ways to set up these systems from index cards to a computer-based system.

The following tracking fields are recommended:

1. Date of inventory.
2. Date chemical received.
3. Specific amount of each chemical.
4. Name, formula and grade of each chemical printed on the container's label.
5. Chemical hazard of each item [Material Safety Data Sheet (MSDS) information and National Fire Protection Association (NFPA) hazard code].
6. Chemical Abstract Service (CAS) registry number.
7. Source (supplier).
8. Container type.
9. Hazard classification.
10. Required storage conditions.
11. Expiration date.
12. Storage location of each chemical.
13. Amount of chemical in the container.

Regularly scheduled inventory inspections should be conducted to delete any inaccurate data in the system and dispose of outdated, unneeded, or deteriorated chemicals following the written Chemical Hygiene Plan.

M. Centrifuge Operation:

Centrifuges can be a useful tool in the laboratory for teacher activity preparation or demonstration but need to be operated safely:

1. Only use a rotor before the manufacturer's expiration or safe-service date.
2. Keep a rotor-use log to prevent overuse. Check the manufacturer's recommendation or specifications as the parameters differ from one machine to another.
3. Clean rotors and buckets with only noncorrosive solutions.
4. Always ensure that loads are evenly balanced before doing a run.
5. Stop the centrifuge immediately if vibration occurs.
6. Never leave the centrifuge unattended.
7. If corrosive or alkaline materials have been run or spilled, be sure to wash affected parts of the centrifuge immediately and allow them to air dry.
8. Never attempt to open the door while the rotor is spinning or attempt to
9. Stop the rotor by hand.
10. Do not attempt to move the centrifuge while it is in operation.

N. Electricity Hazards:

Proper grounding of flammable solvent containers and equipment is needed to prevent protection from static electricity and sparks. Dry air or low humidity fosters static electricity dangers. Sources of sparks and discharges include:

1. Hot plate temperature controls.
2. Light and other control switches.
3. Pulling plugs on energized circuits.
4. Motion of plastic or synthetic materials including clothing.
5. Ungrounded metal objects such as screw drivers, metal electrode strips and aluminum foil.

O. Glassware Hazards:

The leading cause of injury incidents in science laboratories usually involves the use of glassware. Borosilicate glassware is recommended for almost all laboratory work. The following procedures are recommended to reduce or eliminate injuries related to glassware in the chemistry laboratory:

1. Always inspect glassware for cracks and rough edges before using.
2. Discard damaged glassware in appropriate containers.
3. Whenever possible use other types of connections including latex tubing or plastic in lieu of glass.
4. For broken glass, wear appropriate hand protection, sweep small pieces into a pan and dispose in appropriate containers.
5. Always give hot glass time to cool before handling.
6. When inserting glass tubing into rubber stoppers or corks:
 - a) Wear appropriate hand protection.
 - b) Make sure ends are fire-polished.
 - c) Lubricate the glass tubing with glycerol.
 - d) Hold hands close together to limit motion of the glass.
7. Cutting glassware steps:
 - a) Score the glass tubing 1/3 the way of the circumference with a triangular file using a single stroke.
 - b) Wrap the tubing in paper towels or a cloth to protect the hands.
 - c) Place thumbs on both sides of the score mark opposite the score.
 - d) Push away from the body with even pressure on the tube.
8. Vacuum system glassware steps:
 - a) Use only glassware that can withstand external pressure in the established atmosphere.
 - b) Use Erlenmeyer-type round bottom vessels unless glassware is specifically designed for vacuum work.
 - c) Always wrap vessels with duct tape to reduce glass fragment projectiles in case of an incident.
 - d) Always inspect glassware and connections prior to creating the vacuum.
 - e) Use a positive pressure relief device such as a liquid seal.

EARTH/SPACE SCIENCE-BASED PHYSICAL SCIENCE**A. Astronomy:**

Astronomical events such as viewing a solar eclipse are a great opportunity for learning, but safety precautions must be addressed.

1. Never look directly at the sun, including during a solar eclipse. Permanent eye damage is likely to take place.
2. Properly constructed pinhole viewers are a safe way to view the sun.
3. Never view the sun directly through binoculars or telescopes. This can cause blindness.
4. Never use sunglasses or exposed film to view the sun. They do not provide appropriate protection.

B. Geology:**1. Rock and Mineral Study:**

Use the following precautions in working with rocks and minerals in the laboratory:

- a) Use appropriate personal protective equipment such as chemical splash goggles, gloves and aprons.
- b) Use a heavy canvas bag when breaking up rock/mineral samples.
- c) Use proper geologic hammer technique.
- d) Never work with radioactive rocks or specimens.

2. Geological field experience:

Geological field experiences can be exciting and academically rewarding. The following safety precautions should be addressed in preparation for the trip:

- a) Secure information relative to medical conditions in preparation for the field activity from the school nurse and parents. Plan for administration of medication as necessary.
- b) Wear appropriate clothing for the weather conditions.
- c) Use sun sense by wearing appropriate clothing and head gear.
- d) Use appropriate footwear such as boots or sneakers. Flip flops and sandals are unacceptable.
- e) Wear safety glasses or goggles with an ANSI Z87.1 rating. Quarry and cliff type work require use of a safety helmet.
- f) Tetanus shots are suggested.
- g) Rocks and boulders should never be thrown or rolled on the field site. Never touch or try moving rotten trees.
- h) Use caution when hammering rocks.
- i) Use caution when standing near the base of a cliff.

3. Ultraviolet Light

The use of ultraviolet light for mineral study can be dangerous and should be done only as a teacher demonstration.

- a) Protect eyes and skin from exposure of ultraviolet transilluminators.
- b) Wear UV protection rated chemical safety goggles.
- c) Wear long sleeve shirts and lab coat with gloves.
- d) Only use a ground-fault circuit interrupter (GFCI) protected electrical receptacle for the lamp.
- e) Never operate the lamp near water sources.
- f) Never disassemble the lamp when plugged in – this is a high voltage power supply device.

C. Water Studies:

1. Marine Field Trips:

Marine field trips can be useful activities to expand and apply classroom studies. Consider the following safety procedures when planning:

- a) Review weather predictions and prepare appropriately.
- b) Make sure students do not have any open wounds, sores, cuts, etc. prior to going into the water.
- c) Review field hazards and emergency plans with students prior to the start of the activity.
- d) Use foot protection and chemical splash goggles
- e) Be aware of broken glass, fish hooks, rocks and other sharps.
- f) Be watchful for poisonous or stinging marine dwellers like jelly fish, man-of-war.
- g) Always establish boundaries for the area of study.
- h) Provide life jacket for students entering water.
- i) Use sun sense by applying sun screen and appropriate clothing/hat.
- j) One adult should be on beach watch at all times in view of the boundary area.
- k) Remember to bring a cell phone, first aid kit and blanket for emergencies.

2. Stream Tables:

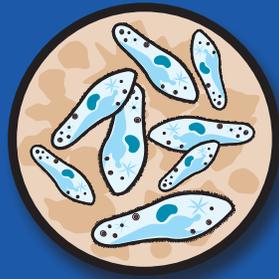
Stream tables can be an effective learning tools. Use the following safety precautions:

- a) Check the table out for leaks, including drain hoses.
- b) Wipe up any spilled water immediately to avoid creating a slip and fall hazard.
- c) Electrical receptacles should be GFCI protected.
- d) Have catch water buckets or receptacles available to catch overflow.

D. Weather Studies:

Weather studies often involve building of weather station equipment. Plan on taking the following safety precautions:

1. Safety precautions need to be addressed and in place when using power tools, electrical devices, hand tools and sharp objects to build equipment. Be certain to file down or sand any sharp edges on materials used to construct weather station equipment after being cut. Never use equipment containing mercury such as thermometers or sling psychrometers.
2. Only adults with formal roof walking and fall protection training should be securing equipment on the roof of a building.



VII. Life Science Laboratory SAFETY SPECIFICATIONS

VII. LIFE SCIENCE LABORATORY SAFETY SPECIFICATIONS

Life science includes branches of science, such as biology, ecology and medicine that deal with living organisms and their organization, life processes, and relationships to each other and their environment.

A. Animal Care:

The use of animals in the science classroom can be a very rewarding educational experience. Investigate and follow local board of education policy relative to care and use of animals in the classroom and laboratory in your school district. With animals comes humane care and appropriate animal husbandry practices. Abuse, mistreatment and neglect of animals are unacceptable. The following safety precautions should be addressed when dealing with animals in the laboratory:

1. Provide adequately sized cages.
2. Make sure cages are cleaned on a regular schedule.
3. Cages should be locked and in an environmentally comfortable location.
4. Check with the nurse for student allergies and make accommodations as needed.
5. Use gloves when handling vertebrates.
6. Always wash hands with soap and water after handling animals in the laboratory.
7. Immediately report and have medical examination of animal bites.
8. Should an animal die unexpectedly, a veterinarian should be contacted to evaluate the animal.
9. Never have poisonous animals in the laboratory.
10. Only secure animals from reputable suppliers.
11. Dispose of animal waste and cage materials in a hygienic manner.

Safety issues relative to visiting animals should also be addressed. Make sure the visiting animal has had all appropriate immunizations and is from a reputable source like Audubon Society and other credible groups. Also review behavioral expectations, care and safety protocols with the animal caretaker in advance of the visit.

B. Biotechnology:

Biotechnology is an exciting relatively new area for course work in middle schools and is becoming more popular. The following procedures for working with biotechnology foster a safer learning experience:

1. DNA and microbes should be handled as if they can cause infections.
2. Handwashing hygiene is required before and after laboratory work by washing with antibacterial soap and water.
3. Gloves, chemical splash goggles and aprons are required.
4. Keep fingers away from eyes, nose and mouth.

5. Decontaminate work surfaces before and after laboratory activities and accidental spills.
6. Use only mechanical pipetting. Never use mouth pipetting techniques.
7. Decontaminate all labware such as glassware that was used in laboratory work by soaking in a 10 percent bleach solution for several hours.
8. Prior to disposal of biologicals, destroy all experimental microorganisms.

C. Bloodborne Pathogens & OPIMs:

Bloodborne pathogens are bacteria, viruses and parasites found in human blood and other body fluids (Other Potentially Infectious Materials, or OPIMs). They can infect and cause disease in humans. The two pathogens recently receiving the greatest attention are the Hepatitis B virus (HBV) and Human Immunodeficiency Virus (HIV). Other pathogens that can also be of concern are herpes, meningitis, tuberculosis, Epstein-Barr virus, Lyme disease, malaria and syphilis, to name a few.

Other potentially infectious materials, or OPIMs, can also foster disease. OPIMs include human body fluids such as semen, vaginal secretions, cerebrospinal fluid, synovial fluid, pleural fluid, pericardial fluid, peritoneal fluid, amniotic fluid, saliva and any other body fluid that is visibly contaminated with blood.

Bloodborne pathogens can be transferred by four different ways — direct, indirect, airborne and vector-borne. Direct and indirect are the biggest threat:

Direct — by touching body fluids from an infected person. This includes contact with lesions, open wounds or sores on the skin. Skin lining of the mouth, nose or throat, and eye contact/invasion, are additional avenues.

Indirect — by touching objects that have touched the blood or another body fluid of an infected person.

Allowing students to do blood work *is not a prudent laboratory practice*, given the risks involved. The Centers for Disease Control, OSHA and other regulatory agencies have clear prudent practices for this purpose.

Based on the means of transmission, life-threatening implications and an individual's right to confidentiality, the potential for bloodborne pathogen infection raises several issues for science teachers in laboratory situations. Although OSHA protects employees and not students, students involved in blood work create an unsafe working environment for employees. The OSHA Bloodborne Pathogen Standard states (29 CFR 1910.1030(d)(1): "Universal precautions shall be observed to prevent contact with blood or other potentially infectious materials." Teachers as employees can just as easily be exposed to bloodborne pathogens from students as they can from other employees. Bloodborne pathogens don't discriminate!

OSHA's Bloodborne Pathogens Standard addresses the blood hazards in the workplace. This standard covers all employees who can "reasonably be anticipated" to have contact with blood and other potentially infectious materials. Science teachers certainly fall under this category and are therefore covered under the bloodborne pathogens standard.

Science teachers, supervisors and their employers need to secure safe alternatives to laboratory activities such as human blood typing, cheek cell sampling and urinalysis.

D. Dissections:

Investigate and follow local board of education policies dealing with dissections. Should plant or animal dissections be used in a class for a laboratory or demonstration, the following safety precautions should be observed:

1. Share the MSDS information with students on the preservative prior to doing any dissection activity.
2. Contact the school nurse to determine if any students have allergies relative to specimen preparation chemicals.
3. Always used chemical splash goggles, gloves and aprons when doing dissection work.
4. Review emergency eye-wash procedures for chemical exposure prior to doing dissection work.
5. Always have the specimen completely rinsed prior to dissection to avoid contact with preservative chemicals.
6. Mount specimens on a dissecting pan in lieu of holding the specimen.
7. Use sharps such as dissection scalpels and blades with caution.
8. Cut away from the body — never toward the body.
9. Never remove any dissected parts from the laboratory.
10. Discard dissected parts in appropriate and labeled waste containers.
11. Always wash hands with soap and water after completing the dissection and cleanup.

E. Electrophoresis:

Electrophoresis is a great opportunity for the laboratory study of DNA sequencing and more. This activity is becoming more popular with the advent of biotechnology studies at the middle school level. However, electrophoresis units tend to operate at relatively high voltages. The following general safety procedures need to be addressed in dealing with this technology:

1. Avoid physical contact to unintentional grounding points and conductors like metal, water sources and jewelry.
2. Work should be located on nonconducting benches and floors. Rubber mats can serve as an insulating surface.
3. Use only ground-fault circuit interrupt (GFCI) protected electrical receptacles for power.
4. Locate the equipment in places where wires will not cause a trip and fall hazard.
5. Prior to use of equipment, inspect and correct items such as cracks, leaks and frayed wires.
6. Use caution making any physical contact with the apparatus. A thin layer of moisture acts as an electrical conductor.
7. Some electrophoresis devices have cooling components or apparatus. Do not contact any cooling apparatus with a gel as the tubing can be a current conductor. Always directly supervise the use of the equipment.
8. Exercise caution in working with power supplies that produce high voltage surges when first energized. Should the electrophoresis buffer spill or leak, stop the operation and clean up the spill immediately.
9. Use and post appropriate “Danger – High Voltage” warning signage on power supply and buffer tanks.
10. Upon completion of work, always wait 15 seconds for capacitor discharge after shutting off the power supply before making any disconnections or connections.

F. Field Activities:

Field experiences in biology classes help provide applications to classroom curriculum studies. In preparing for a field experience, the following safety preparations and precautions should be taken:

1. In planning for field work, review board of education field trip policies.
2. Secure information from parents and the school nurse relative to student medical needs, allergies and contact information.
3. Written permission to obtain help for special needs should also be secured in advance.
4. If laboratory chemicals are used during the field work, MSDS sheets are required on the trip.
5. Communications are essential during field work. Bring a cell phone or two way long range radio to keep in touch with the school.
6. West Nile virus, Lyme disease and other insect-borne diseases are real threats. Use appropriate dress (long sleeve shirts, pants, closed-toe shoes or sneakers) and repellents for insects. Make sure that you've informed parents in advance about the use of repellents, so that potential allergies can be avoided.
7. Have a behavior contract that everyone understands, with consequences that everyone will support.
8. Use chemical splash goggles and gloves when working in the field with river, pond or lake water, water testing chemicals and any other materials/activities that may prove hazardous to the eyes.
9. Use good sun sense by having students and teacher wear long sleeves, long pants, large-brimmed hats, sunglasses and sunscreen (SPF 30 minimum).

G. Heat Sources:

1. Autoclaves/Pressure Cookers

Autoclaves can be dangerous given high pressures and temperatures. Only science teachers or trained science paraprofessionals should operate these devices. Apply the following safety precautions when using autoclaves:

- a) Inspect the autoclave door and gaskets to make sure they are firmly locked in place.
- b) Post signage on autoclave warning of "hot surfaces, keep away."
- c) Never place combustible or flammable materials near or on the autoclave.
- d) Wear heat-resistant gloves, apron and chemical splash goggles.
- e) Do not leave the autoclave unattended during operation.
- f) Shut down the autoclave should there be any indication of a leak.

Pressure cookers are less expensive than autoclaves and may be useful in simple laboratory sterilization procedures. They can be equally as dangerous as autoclaves at high pressures and temperatures. Their use is not advocated given the potential for explosion in the case of faulty pressure release valves. However, if pressure cookers are to be used, follow these safety tips:

- a) Older pressure cookers have fewer safety features and have the potential to explode if not operating correctly. Always inspect the device to make sure clamps are securely attached, the gasket seal is in place, and the vent tube is clear.
- b) Make sure the vent tube is clear and operational.

- c) Never touch the cooker until it is cooled down.
- d) Never leave the cooker unattended during operation.

2. Bunsen Burners

Bunsen burners can be dangerous as a heat source, given their hot flame. The use of hot plates can be safer and is preferred at the middle school level. Use the following safety hints for a safer operation if gas burners are used:

- a) Make sure hair is tied back.
- b) Always wear chemical splash goggles.
- c) Light the burner at arms length using an igniter or splint.
- d) Do not operate the burner with acrylic nails.
- e) Never leave the burner unattended.
- f) Do not touch the burner until it has had time to cool off.
- g) Do not operate the burner while igniting it.

3. Hot Plates

Hot plates are a major heat source in biology laboratories. They are easy to operate and less dangerous than gas burners.

- a) Always inspect wiring on hot plates before use. Make sure insulation is in place and all prongs are on the plug.
- b) Plug the hot plate into a GFCI protected wall receptacle.
- c) Never touch a hot plate that has been in operation until it cools.
- d) Never tie the cord around a heated hot plate.
- e) Never leave a hot plate unattended.

B. Microbes:

Microbe study in the laboratory requires special precautions given the opportunity of pathogenic bacteria exposure. This is especially true today with the ever increasing number of immune-challenged students and antibiotic-resistant strains of bacteria. Bacterial cultures should only be done as teacher demonstration at the middle school level with safe bacteria sources, such as live yogurt and kefir cultures. Commercially prepared preserved bacteria slides are also a safer alternative to live cultures. However, students can be involved in activities reflecting the presence and activities of bacteria. There are a number of laboratory test strips available from biological supply houses and pharmacies that can be used to detect the by products of bacterial action. An additional alternative is the use of yeast cultures for student use.

The following safety protocols should be strictly enforced with any bacterial work:

1. Personal protective equipment such as chemical splash goggles, lab coat or apron, and gloves are required during the laboratory activity.
2. Make sure all skin scratches and cuts are covered with bandages.

3. Before and after laboratory activities, wash the work area with disinfectant.
4. Absolutely no food or drink is allowed in the laboratory.
5. Keep sources of potential contamination such as pencils, hands and laboratory equipment away from body orifices such as mouth, ears and nose to prevent potential contamination.
6. Have disinfectant tray available for the discard of contaminated equipment such as pipettes, petri dishes and more.
7. Should there be an accidental spill of microbial organisms, immediately contain it with dry paper towels. Sterilize the paper towels and disinfect the area of the spill.
8. No general survey collections should be cultured given the danger of pathogenic organisms. An effective alternative can be commercially prepared slides.
9. All bacteria cultures and petri plates should be autoclaved or microwaved prior to disposal.
10. Wash hands with antibacterial soap and water after completing the laboratory work and cleaning up.

C. Microwaves:

Microwave ovens can be used as both a heating source and decontamination device. Simple safety precautions include the following:

1. Never operate the microwave oven when empty.
2. Always check the door seal prior to use to make sure it does not have a breach.
3. Persons with pacemakers should not be near the oven when operating.
4. Never place metal objects such as aluminum foil in the oven.
5. Do not put face near the oven door while operation.
6. Make sure the inside surface of the microwave is clean.
7. Post proper signage warning of microwave use.

D. Plants:

The study of plants is both interesting and relevant to everyday life from food sources, oxygen production and energy sources. However, plants can also produce toxic substances that can put human life in harm's way. Be certain to follow the following safety plan when dealing with plants in the laboratory:

1. Check with the school nurse for potential allergy issues for students. Make accommodations as necessary.
2. Wear safety splash goggles, gloves and aprons when working with plants.
3. Never have poisonous plants or plants producing allergens in the laboratory.
4. Inform about the difference between edible and nonedible plants
5. No plant part should be tasted without specific direction from the teacher.
6. No parts of plants should be burned that have allergen-type oils such as poison ivy and poison oak.
7. Wash hands with soap and water after working with plants.

E. Refrigerator:

1. Never store food in any refrigerator or freezer used to store chemicals.
2. Refrigerators and freezers should be cleaned out on a regular basis.
3. Containers placed in a refrigerator or freezer should be completely sealed or capped, securely placed and labeled.
4. Avoid capping materials with aluminum foil, corks and glass stoppers.
5. All liquid chemicals should be stored in plastic trays.
6. All specimens should be stored in plastic bags with labels.
7. All items stored are to be appropriately labeled.
8. Review inventory on refrigerator/freezer contents to ensure compatibility of the contents.
9. Store only chemicals in amounts needed over a reasonable amount of time. Each chemical has a shelf-life and decomposition products that could be hazardous.
10. Remember that power outages and technology failure can have an impact on stored contents. Be aware of unusual odors or vapors.
11. Do not use glass beakers as lids for bottles.
12. Do not stack materials too high.
13. Do not use graduated cylinders or volumetric flasks to store materials.
14. Refrigerators/freezers should be periodically inspected (i.e., at least monthly).
15. Post an up-to-date inventory on the refrigerator door.
16. If potentially infectious material is spilled, clean immediately with a disinfectant agent such as 70 percent isopropyl alcohol. Then, wipe down the area with soap and water.
17. The refrigerator/freezer must be properly grounded and a permanent installation (i.e., no extension cords).
18. The refrigerator/freezer must be located away from lab exits.

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