Standard Operating Procedures
Science Classroom Safety

Responsibilities of the Teacher:

- Instruct students in emergency plans and the established procedure for handling emergencies.
- Provide verbal and written safety guidelines based on safe laboratory practices at the beginning of the year.
- Review safety precautions verbally with students before each activity
- Document the safety measures you and the students will take for each lab activity in daily lesson plans.
- Use safety contracts and tests (see Appendix C) to insure student accountability. Reinforce as needed.
- Before choosing and conducting a science activity, investigate and weigh risk vs. benefits.
- Do not perform a demonstration for the first time during class. Do the demo with other instructors and evaluate for safety, considering risk vs. benefit.
- Plan lessons and activities with consideration to minimizing all chemical exposure.
- Understand the potential hazards of all materials, processes, and equipment that will be used.
- Have students document safety equipment used and precautions taken in written lab notebooks and reports.
- Know location and how to use safety equipment (fire blanket, fire extinguisher, eyewash, spill containment equipment, etc.)
- Train students in the location and proper use of appropriate safety equipment.
- Report accidents to the administration and the school nurse on the appropriate form (see Appendix C)
- Implement a firm policy regarding the use of appropriate protective eyewear.
- Model safe behavior. Wear goggles.
- Post visual displays, posters, safety rules, and procedures.
- Do not overlook infractions of safety rules.
- Know and understand the hazards of any chemical used as stated on the MSDS
- Be aware of common poisonous materials and possible student allergies or reactions to them.
- Keep an appropriately stocked first aid kit on hand.
- Have a written first aid policy explaining the actions to take, in order.
- Use a safety shield for strongly exothermic demonstrations or those involving projectiles.
- Be aware of current safety research and regulations.
- Know and understand the district's chemical hygiene plan.

The Science Classroom:

- Know what to do in the event of a power failure.
- Never leave students unsupervised.
- Read every chemical label twice before use.
- Inspect for potential hazards as a routine; do a regular annual inspection using the form in the Appendix C to report existing and potential hazards to the principal in writing.
- Provide instruction for students in the proper use of all safety equipment as appropriate.
- Instruct students in the use of MSDS and keep a classroom reference set.
- Be attentive to humane care, handling, and treatment of animals in the classroom.

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- Post emergency telephone numbers in a conspicuous place in the classroom.
- Lock unoccupied science classrooms and all equipment and chemical storage areas.
- Store chemicals by families as recommended in the Flinn catalog.
- Science classrooms should be used for science classes only.
- Routinely inventory all equipment and materials

Supplies and Equipment:

- Avoid skin contact with chemicals.
- Do not underestimate chemical risks and hazards.
- Keep all equipment in working order.
- Store and use flammable chemicals appropriately; never near an ignition source such as a spark or open flame.
- Do not store chemicals beneath a sink, above a sink, or near a sink.
- Do not permit students to use broken or unsafe equipment or chipped or cracked glassware.
- Store and transport hazardous materials in suitable secondary containers.
- Store and maintain supplies and equipment in a manner that promotes safety.
- Allow only authorized persons in storage areas.
- Dispose of unwanted chemicals promptly and properly.
- Treat spills and the materials used to clean them up as disposal concerns.
- Accept donations of materials (other than literature) with administrative approval only.
- Do not permit students to take home laboratory glassware, equipment, or chemicals.
- Report missing materials to the appropriate authorities.
-

General Safety Practices

- Never work alone in the laboratory, including prep and storage areas.
- Goggles must be worn by anyone in the lab whenever chemicals, glassware, or heat is used.
- Know the school procedure for handling accidents.
- Instruct students not to taste chemicals of laboratory materials.
- No eating or drinking in the science laboratory. Use common sense when doing edible projects.
- Teach and practice safety precautions when working with electrical current.
- Store only minimal amounts of properly labeled chemicals in the classroom.
- Know location of and operation of electrical, gas, and water shutoffs.
- Be aware of physical, mental, emotional, or cosmetic factors that may pose a risk for any student.
- Know medical predispositions of students, which may put them at risk – allergies, seizure disorders, pregnancy, etc.
- Keep MSDS and chemical inventory (name, amount, storage location) in the classroom and in a central department area.
- Collaborate with colleagues to review and update lab activities in keeping with current safety standards.
- Establish a written specific safety plan for each individual building.

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Elementary School Science Safety

Elementary school children are insatiably curious. Children learn science by doing science. The elementary classroom is the first exposure most children have with safety practices that will serve them in situations from dealing with household chemicals to occupational conditions later in life. Teaching children to investigate appropriately and with safety first will provide students with a firm foundation in the practice of science.

The Role of the Teacher

The elementary science teacher is a child's first role model outside the home. Elementary teachers have the privilege and responsibility to foster a child's excitement and instill a sense of respect and responsibility toward nature and the physical world. The elementary teacher shapes habits that will carry a student through college and into the workplace. The modeling of safe practices and attitudes in early science experiences is of great impact in the development of the student.

First Steps toward Safety

Early in the year, explain safe behavior to students. Use every opportunity to discuss safety and display safe practices.

Martin (1977) suggests the focus should be on:

- Cooperation between you and the children and between each other.
- Orderly behavior reduces the likelihood of accidents.
- Listening for your voice as children go about their activities enables students to hear additional instructions
- Common sense must be invoked at all times when dealing with science activities

Goggles and Safety Equipment

Everyone in the classroom will wear goggles whenever heat, glassware, or chemicals are in use. It is advisable to wear eye protection whenever projectiles or possible projectiles are in use as well. Eye protection must meet ANSI Z87 safety standards and must be chemical splash goggles if used with chemicals. Z87 will be stamped on the goggles if the standard is met. The Z87 rating does NOT indicate the goggle is chemical splash resistant.

Lesson Plans

Students must be actively taught to be safe in the science classroom. Lesson plans should contain details about the safe use of science materials and equipment, the location and proper operation of safety equipment, rules governing student behavior, and the responsibilities of students for safe classroom practices. These early lessons need to be reinforced until all students have demonstrated proficiency. Safety considerations should become part of each lesson plan that involves any possible hazards and students need to be instructed as to how to avoid these hazards.

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Laboratory Activities

- Try any procedure yourself before using it with students as either an activity or a demonstration. Watch for potential hazards and point them out to students prior to undertaking any lab work.
- Spend a few minutes reviewing a procedure with students before beginning an activity.
- Conduct a "hazard review" with the students as you point out potential hazards. Discuss possible dangers and focus on consequences of what could happen if procedures are not followed and followed correctly.
- Review the emergency procedure to be used if things do not go as planned.

Plants and Animals

All plants and animals brought into the classroom require special care and handling. Some species may present a greater hazard than others to individual students. For specific information, please refer to the following pages of this document: (INSERT PAGE NUMBERS HERE)

Summary of Safe Classroom Practices

Planning includes:

- Doing the lab previously to become familiar with the procedure, materials, and time frame.
- Outlining of safety procedures for a given activity and documenting these considerations into the lesson plan.
- Taking steps to insure the student's knowledge and accountability of safety practices.

Organization includes:

- concise and easily understood written and verbal directions for a lab activity
- materials being measured and prepared ahead of time.
- equipment should be procured and checked ahead of time as well.

Troubleshooting includes:

- identifying all the possible hazards of an activity and taking steps to minimize the dangers.
- If the potential hazards outweigh the benefits, consider modifying or omitting the activity.

Safety Checklist for Elementary Teachers

- Develop a safety unit and teach students the proper way to use and handle instruments, equipment, and chemicals.
- Provide /emergency verbal and written safety instructions to students.
- Have students and parents sign a safety contract.
- Review safety procedures personally and with students before each activity.
- At the start of each science activity, instruct students regarding potential hazards and the precautions to be taken.
- Document all safety instructions and the instructional method of delivery in lesson plans for each activity.
- Instruct students that all accidents or injuries, no matter how small, should be reported to the teacher immediately.
- Train students to locate and use safety / emergency equipment as appropriate for age.

- Students should be instructed never to taste or touch substances in the science classroom without first obtaining specific instructions from the teacher.
- Model proper safety behavior for students. Wear your goggles.
- Insist that all classroom visitors also follow proper safety procedures.
- Do periodic safety inspections of the classroom and all safety equipment.
- Post written safety rules and safety policies in your classroom.
- Know and teach students your building's policies for emergency procedures and evacuation as appropriate.
- Develop an emergency plan among the teachers in your building. Instruct students and teachers in what to do, where to go, whom to contact, etc, in case of an emergency.
- Safety concepts to cover with your classes as appropriate:
  - Use of safety goggles
  - Proper use of microscopes
  - Location of safety equipment
  - Appropriate dress for lab
  - Use of gloves and aprons
  - How to dispose of broken glass
  - Fire prevention
  - Safety procedures for dissection of specimens

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Middle School

Formal laboratory experiences in the middle school are a continuation of elementary school activities that prepare the student for more complex and self-directed work in the high school and beyond. At this stage, safety continues to be a learned skill more necessary than any other laboratory technique. The maturity, age, and skills of these students should dictate the planning and monitoring of laboratory lessons. The teacher should demonstrate safe behavior and correct procedures before each lab activity. Students should be taught to take on safety as a prime responsibility when conducting scientific investigations.

Lesson Plans

Students must actively be taught to be safe in the science classroom. Lesson plans should include details about the safe use of classroom materials and equipment, the location and proper operation of safety equipment, the rules for and responsibilities of students.

Student proficiency with safety lessons needs to be tested until all students have demonstrated mastery. Teachers should file evidence of student safety knowledge and application. Safety considerations should become part of each lesson plan that involves any possible hazards and need to be instructed about avoiding them.

Classroom Facilities

Remind students constantly of safety considerations through the use of signs and posters. All safety equipment should be prominently marked with signs. Use student safety contracts, signed by both students and parents, to reinforce the importance of safe science. (See Appendix C for a sample middle school science safety student contract.)

The teacher should, if possible, locate and be able to operate master classroom electricity, gas, and water shutoff controls. Each science classroom should have a Tri-Class fire extinguisher, safety shower, fire blanket, and first-aid kit. Electrical outlets should be of the grounded type and equipment power cords should be frequently inspected. Extension cords may be used so long as they are grounded, secured out of student areas, off the floor, and meet the approval of the fire marshal as he inspects. Students should know the location and proper use of the classroom fire extinguisher and eyewash station.

Life Science Safety Concerns

Animals in the Classroom

- Know the National Biology Teachers and National Science Teachers Association Rules governing the use of animals in the classroom. These can be found in Gerlovich (1985), pp 150-155 and Vicus (1978) pp 80-81.
- The animals' well being is of prime importance.
- Provide a healthy and proper environment.
- Use plants rather than animals when possible.
- Plan activities that are within the capabilities of the students.
- Animals should be returned to a normal diet at the conclusion of any diet experiments.
- Vivisection (the cutting into or experimentation with live animals) is not permitted.

- Wear gloves and handle animals carefully to avoid scratches and bites that may cause transmission of harmful disease.

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- Students should be familiar with the identification of protected or regulated animals that inhabit the general region of a collection site.
- Do not bring imported exotic animals, wild animals, injured or stray animals, or known poisonous animals in the classroom
- Biological supply houses provide instructions for care of live materials. Follow them.

Animal Dissection

- Be aware of any student who may be put under physical or psychological stress when using preserved specimens
- Monitor for any signs of student illness as a result of exposure to chemicals used in specimen preparation.
- Avoid contact with preservative chemicals (formaldehyde and formalin). It is suggested to soak specimens in water for 24 hours prior to student dissection if the specimens are not preserved in a non-toxic preservative that is not formaldehyde or formalin based,. An eyewash station should be available.
- OSHA approved chemical splash goggles must be worn.
- Provide adequate ventilation during dissection.
- Some preservatives are especially irritating to students wearing contact lenses and produce fumes that may be absorbed by the contact lenses.
- Properly mount dissection specimens to dissecting pan. Do not dissect a specimen while holding it.
- Use only single edged razor blades or scalpels and handle with extreme care.
- Students should always cut in a direction away from their bodies and away from other students.
- Students should be cautioned never to ingest specimen parts.
- Students should not be allowed to remove specimens or specimen parts from the classroom.
- All parts of the specimen must remain in the dissecting pan.
- Properly dispose of dissected material.
- Store specimens in accordance with their directions.
- Clean up the work area and return all equipment to the proper place.
- Wash hands after dissecting.

Microscope Investigations

- Instruct students in the proper use of the microscope.
- Avoid the use of pathogens and tumor-producing agents.
- Solutions of vinegar, salt water, and iodine should be handled with care.
- Students should wear goggles while preparing slides as they are handling glass and chemicals and possibly heat.
- Carry the microscope with one hand on the microscope arm and the other under the base.
- Do not use direct sunlight as a light source.
- Be careful when using glass slides and cover slips because they are sharp.
- Under no circumstances should equipment used in personal experiments be shared (ex. Straws, toothpicks, spoons, tongue depressors, etc)
- Use Lysol or bleach diluted 1 cup in 1 gallon of water to disinfect if needed.
- Return all equipment to its proper location.

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Plants in the Classroom

- Avoid distribution of pollen-bearing plants in full bloom or mold-infested substances in the classroom. Use fresh samples and plants, which are not in full bloom.
- Be able to identify protected or regulated plants found in the general area of a collection site. (see Gerlovich {1985} pp 148-149)
- Be able to identify common poisonous plants native to the general area of a collection site.
- Monitor student for any sign of illness as a result of exposure to plants, pollen, or fungal spores.

Glassware

- Use plastic substitutes for glassware, whenever possible
- Do not permit students to use chipped or cracked glassware.
- Never eat or drink out of laboratory-use glassware
- Do not apply extreme force to any glass object.
- Do not shake down or swing thermometers.
- Use alcohol thermometers instead of mercury thermometers.
- Use Pyrex glassware where indicated.
- Do not use damaged or chipped glassware.
- Dispose of broken glassware in a specially marked container.

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Earth/Space Science Safety Concerns

Earth science laboratory experiences make use of a variety of supplies and equipment that have safety considerations. Please consult the Physical Science Concerns in the Middle School and the High School Chemistry sections for the proper safety precautions needed in handling and storing these chemicals.

Some special concerns for the earth science teachers are:

- Chemical storage and theft
- Crystal growing chemicals
- Eclipse viewing
- Eye protection
- Flame or borax bead tests
- Gas burners and hot plates
- Glassware
- Lapidary work
- Mercury thermometers
- Model rocket demonstrations
- Rock and mineral toxicity
- Spectrum tubes
- Volcano demos

Below are some points to remember when dealing with the variety of materials used in an effectively experimental earth science course.

Chemicals:

- All chemicals must be stored in locked cabinets and in small quantities only.
- MSDS sheets must be on file in the department office and the main office for each chemical. Care should be taken to insure that no chemicals are removed from the classroom.
- Under no circumstances should chemicals or equipment ever be given to students for use at home.
- Do not accept donations of chemicals or equipment without the approval the department chair. Some agencies use schools as "dumping grounds" to rid themselves of liability.
- The following chemicals are safe to use as demonstrations in the classroom;
    - aluminum potassium sulfate
    - potassium sodium tartrate
    - sodium chloride
    - sucrose.
- Use MSDS and the Flinn Scientific Catalog to guide storage, use, and disposal procedures
- Mercury is an insidious chemical hazard by skin absorption and inhalation. The vapor produces a long-term contamination that is especially harmful to the teacher. Dispose properly of all mercury thermometers and use only non-mercury thermometers.
- Learn how to clean up mercury spills. (Flinn [1998] pp 127-128.
- Dispose of solutions of these chemicals by flushing them down sink drains with lots of water
- Demonstrations of burning coal should be avoided.
- Demonstrations of volcanic eruptions using ammonium dichromate should never be attempted in the classroom. Many chromium compounds are suspected carcinogens.

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Eclipses and Eye Safety

- Never allow students to look at the sun directly or with any optical devices (sunglasses, magnifying lens, telescopes, etc.)
- For eclipses viewing, require students use only the pinhole method where the sun's image is focused by a pinhole in a sheet of paper onto another sheet of paper. Any other method can cause permanent eye damage.
- All persons present if there is an activity occurring in the classroom that poses an eye hazard, for example, whenever chemicals, glassware, or heat are present, must wear goggles.
- OSHA approved chemical splash goggles stamped ANSI Z87 will be used.
- Students using flame or borax bead tests for rock and mineral identification must use eye protection and extreme care with an open flame. Avoid inhalation of vapors.
- Portable propane burners are not permitted. Use great care when using natural gas burners or electric hot plates. Eye protection must be work when heating any material.
- Use eye protection when heating, mixing, reacting, or transferring chemicals in any glassware.

Glassware

- Carefully instruct students about the safety considerations involved in bending and use of glass tubing.
- Only Pyrex or Kimax brand glassware should be used for heating or reacting chemicals.
- Inspect glassware before use. Discard all glassware found to be chipped or cracked.

Lapidary and Rock Grinding

- Treat all rock grinding and tumbling equipment as hazardous.
- Lapidary work always requires eye protection and body covering (aprons.)

Model Rocketry

Model rocket launches add realism to the earth science class. All model rocket programs must conform to the National Association of Rocketry (NAR) safety code. A copy of this code can be found in the safety resources in Virkus (18978) pp 95-96.

- Use only commercially produced rocket engines.
- Never produce or experiment with "home-made" engines.

Rock and Mineral Identification Methodology:

While rocks and mineral identification is a safe and educationally valuable activity, care should be exercised in the following areas:

- never break rock or mineral samples without proper eye protection
- never use asbestos samples
- use only dilute HCl (0.1M) in small dropping bottles;
- caution students about the hazards of lead poisoning;
- always require students to wash hands after handling rock and mineral samples

Miscellaneous

- Students with long hair need to have it tied back; long sleeves need to be rolled up; loose fitting or bulky clothing needs to be avoided; necklaces and rings need to be removed.
- Constant supervision of student work and the work area is necessary.

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- The power supplies needed to operate spectrum tubes carry dangerously high voltages and the connections are often exposed. Instructions to students are necessary to avoid electrical shock.

General Safety

- Science classroom safety is a matter of preparation and consideration. Carefully weigh the risks of any activity against its educational value.
- Understand the potential hazards of any activity or experiment.
- Avoid the idea of, "If I only do it once, nothing will happen."
- Complete a Preliminary Accident Investigation Report (GH-20) for any injury that occurs in the classroom. (see the appendix for a copy of this form.)
- MSDS must be on file in the department office and the storage area for each substance used.
- Avoid activities that are beyond the capabilities of students.
- Become a role model of good science safety for our students.

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High School

Laboratory work is an integral mechanism in student learning. Carefully planned laboratory experiences are instrumental in enhancing student understanding of scientific concepts. Laboratory research and exploration reinforces cognitive knowledge, and support science education as a hands-on subject. A key feature of the high school curriculum is well-planned laboratory experiences. Creating a safe laboratory environment is a necessary part of the curriculum. It requires planning, organization, and a certain amount of troubleshooting.

Each discipline in science uses glassware, heat, or chemicals in some manner. Read the guidelines in the Chemistry section and follow them as you manage your chemical inventory.

Planning refers to the teacher having done the lab previously to become familiar with the procedures and time requirements. It includes outlining safety procedures for a given activity and documenting these safety considerations in lesson plans.. Planning can also refer to the teacher taking steps to insure student knowledge and accountability for safety practices.

Organization refers to concise and easily understood written and verbal instructions for a lab activity, as well as materials being prepared and measured out ahead of time. It includes equipment being procured and checked to see that it is operational and safe.

Troubleshooting refers to identifying all the possible hazards of an activity and taking steps to minimize the dangers. If the potential hazards outweigh the potential educational value, the activity should be modified or omitted.

There needs to be a concomitant increase of student and teacher awareness of good safety practices in order to minimize risks to a practical level. This chapter is designed to strengthen teachers' knowledge of safety concerns so that they can model safety practices for their students to emulate.

Lesson Plans

In the classroom, science teachers need to make health and safety an integral part of their instruction. Ultimately, it is the teacher's responsibility to make certain that proper safety considerations have been made and the appropriate precautions have been taken. These safety features should be documented in the teacher's lesson plans.
Kaufman (1989) suggests that in preparation of class activities, teachers ask themselves the following questions about each activity:

- What are the risks associated with this activity?
- What are its worst possible outcomes?
- What do I need to do to be prepared if these outcomes should occur?
- What practices, equipment, and facilities would reduce risk?
- How can I relate these hazards to dangers my students face in their everyday lives?

Student Accountability

Not only are teachers held accountable for appropriate safety procedures, but students must be also. It is the teacher's responsibility that all students learn and practice the proper safety rules, have the opportunity to develop and practice the necessary safety skills, and therefore develop positive attitudes about safety. (Vos & Pell, 1990).

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The following list provides suggestions for the teacher to achieve these goals of student safety:

- Have a plan for how to teach students the desired safety practices.
- Have students brainstorm potential hazards and identify possible consequences.
- Involve students in planning for safety to identify possible consequences.
- Post written rules and safety policies in the room.
- Provide each student with a written copy of the rules and safety policies.
- Demonstrate and/or role-play various safety practices.
- Test students to assess their levels of understanding of safety practices and reteach, if needed.
- Have students and their parents sign a safety contract. (See Appendix ___ for appropriate examples)
- Teachers should keep students' tests, contracts, and other information pertaining to their safety education program.
- Have students identify location of safety equipment on a blank map of the class/lab room.
- Do not overlook any infraction of a safety procedure.
- Continuously reinforce and review safety practices.
- Model good safety behavior for your students to emulate.
- Fully explain the consequences for not complying with the appropriate safety practices.
- Each student should know the location of and how to use all the safety/emergence equipment in each lab room.
- Each student should dress appropriately for lab:
    - Roll up long sleeves above elbows.
    - Avoid loose and bulky clothing.
    - Remove bulky jewelry or long-hanging necklaces.
    - Long hair should be tied back.
    - No open-toed shoes are permitted.
    - Contact lens wearers should have approval from eye doctor.

General High School Safety Issues

Included in this section:

- The Laboratory Facility
- General Laboratory Rules and Procedures
- Storage of Chemicals
- Glassware
- Heat Sources
- Autoclaving (pressure cooker)
- Fire Prevention
- Steps in Fire Prevention
- Eye Protection
- Work Space
- Student Assistants
- Personal Hygiene and Protective Clothing Requirements

The Laboratory Facility

- The laboratory should be well ventilated. The fan should remove the air at a minimum of 8 air changes per hour. Air should move directly into the laboratory from non-laboratory areas and out to the exterior of the building. Check ventilation at least every 3 months.

- Install a telephone in a central location in the laboratory area. Post emergency telephone numbers visibly near the telephone.
- The eyewash must be capable of treating both eyes continuously for 15 minutes with copies quantities of potable water. All students and teachers in the area should be trained in its use. Flush the eyewash at least once per month. Inspect the eyewash every 3 months.
- Equip all laboratories with TriClass fire extinguishers
- Be sure fire exits are not blocked
- Plan and post evacuation routes, including alternate routes.
- Keep aisles clear.
- Have spill kits consisting of dry sand, kitty litter, or other spill containment materials readily available.
- Provide safety showers and/or body drenches. Flush once each month; check flow every 6 months.
- Do not store chemicals in the fume hood.

General Laboratory Rules and Procedures

- Do not run or allow horseplay in the laboratory.
- Fill out an accident report for every incident, no matter how seemingly small.
- Analyze incidents and near incidents and share with those who might learn from them.
- Be sure hands, feet, tabletop, and electrical equipment is dry before operating it.
- Practice the emergency procedure with your students and staff.
- Do not allow food, beverages, or chewing gum in the laboratory.
- Do not allow students to apply cosmetics in areas where chemicals are used.
- Never perform unauthorized laboratory experiments
- Know the hazards and precautions stated on the MSDS before using any chemical. Follow them.
- Do not mouth pipet.

Storage of Chemicals

The necessity of storing a variety of chemicals with a diversity of properties and reactivities creates special hazards, which must be readily recognized and prevented. For more specific information, refer to the Chemistry section in this booklet; Flinn (1998), p. 572 ff.: Gerlovich (1985) pp 53-71; or Virkus (1978) pp 37-40.

- Keep all chemicals in the prep and storage areas. Return chemicals taken to the classroom at the end of each day.
- Store chemicals by families, not alphabetically. (references, above)
- Annually inventory all chemicals. Copies of the school's most current inventory should be kept in the storeroom and in the department office.
- Governmental regulations require a MSDS to be on file for every chemical in the lab.
- Label all chemicals with name, chemical formula, date received, and date opened.
- Dispose of unidentifiable or unlabeled chemicals and outdated chemicals in the appropriate manner. Conform to local and state regulations. Ref; Chemical Disposal Procedures, Flinn C
- Known carcinogens should not be kept in schools. See Appendix for list.
- Read all labels twice before using the contents.
- Never add water to acid. Always add small amounts of acid to the water.
- Identify any unstable substances in the lab and take the required precautions. See Virkus (1978), pp 48-50. The following substances are considered to be instable. It is suggested that these substances be eliminated from use:

- Ether
- Ammonium nitrate
- Formic acid
- Sodium, potassium, lithium
- Phosphorus
- Ammoniacal silver nitrate
- Benzoyl peroxide
- Nitrogen tri-iodide
- Picric acid, metal picrates, and perchloric acid
- Strong oxidezers, including hypochlorite, permanganates, chlorates, and bromates
- Cyanides

- Do not store any unlabeled products. Make every effort to identify them. If you cannot identify them, have them professionally removed.
- Storage rooms are to be kept locked when not in use.
- Students are not to be in the storage room.

Glassware

- Follow recommended procedures for cutting glass tubing with either a file or the hot wire method. See Virkus (1978), p 27 for complete explanation.
- Do not have students insert glass tubing. Teachers should do this procedure. Always use glass tubing with fire polished ends. Lubricate glass tubing and stopper hole with glycerin and twist glass tubing into stopper hole. Wrap glass tube with towel or wear gloves.
- Do not use glassware for mixing potentially explosive compounds.
- Always use a bulb to pipette. NEVER mouth pipette.
- Frozen glass-to-glass surfaces (e.g., stopcocks or glass-stoppered bottles) can be opened by applying a stream of hot water to the stopper. Wear gloves or protect the hands with a towel.
- Leave sufficient air space in bottles filled with liquids to allow for expansion.
- Never use laboratory glassware for eating or drinking.
- Do not use chipped, cracked, or broken glassware.
- There should be a separate, labeled container for broken glass.

Heat Sources

- It is always preferable to use a hot plate as a heat source as opposed to an open flame.
- If using alcohol burners, use only alcohol or designated burner fuels. Add some salt to the burner fuel supply to color the flames (orange.) Otherwise, alcohol burner flames tend to be invisible and increase probability of burns.
- Never refill alcohol burners during class.
- Extreme caution should be used with a gas burner. Keep head and clothing away from flame. Turn the flame off when it is not in use.

Autoclaving (pressure cooker)

- The teacher should be thoroughly familiar with the operation of the autoclave.
- Examine safety valve and check that it works.
- Tighten wing nuts evenly by tightening down two opposite wing nuts simultaneously.
- Keep the pressure (gauge reading) below 20 pounds.

- Allow the pressure to return to zero before trying to remove the cover.
- Open the test stopcock before releasing the wing nuts.
- Use eye protection when working with autoclave under pressure.
- Sterilization requires 15 minutes at 15 pounds of pressure (psi.)

Fire Prevention

It is the responsibility of each science teacher to act intelligently and immediately in the event of a fire in the classroom. The first concern is to get the students out of the area.

Types of Fires and Fire Extinguishers:

There are 4 general classes of fire. The classification is based on the type of material that is being consumed.

Class A – Paper and trash: wood, textiles, etc.
Class B – Flammable liquid: gasoline, oil, paint, etc.
Class C – Electrical
Class D – Flammable metals; magnesium, sodium, potassium.

The use of the appropriate type of fire extinguisher for each class will provide optimum control. The Maintenance Dept. has placed appropriate extinguishers in science facilities. Refer all questions to the Business Manager.

Class A – Water extinguishers are the most effective. Use ONLY for Class A fires.

Class B and Class C – Carbon dioxide or dry powder extinguishers containing sodium bicarbonate are effective. Carbon dioxide extinguishers are particularly well suited for electrical fires. Sodium bicarbonate extinguishers are particularly well suited for flammable liquid fires.

Class D: Flammable metal fires are best extinguished with dry sand or special granular formulations.

Fire Blankets:- The proper use of blankets should also be demonstrated to students. There is some controversy over whether to use a fire blanket to extinguish a person's skin or clothing. The majority of evidence suggests that laying down a person whose clothing is on fire and rolling him over in a blanket is the safest and most expedient method to use (Gerlovich, 1985). However, the roll need not include a blanket.

Steps in Fire Prevention

- Both the teacher and students should know the type of fire extinguisher available and its limitations.
- Students should be instructed in how to use a fire extinguisher. Representatives from the local fire department may agree to give a demonstration.
- The ABC type (multi-purpose dry chemical) would be preferred.
    - NEVER use a carbon dioxide extinguisher on an individual. It could spread the fire and possibly cause frostbite.
    - The first step in an electrical fire is to pull the plug.
    - Both the teacher and students should know the location of:
    - Fire extinguishers in the classroom
    - Fire extinguishers in the hallway
    - Fire alarms
    - Fire blanket
- Identify the type of fire extinguisher available to you
- Clearly mark the location of the fire blanket.
- A fire blanket may also be used to smother a small fire.

Eye Protection

Eye protective equipment appropriate to the course must be provided. The state of Ohio requires that ALL students wear chemical splash goggles if there is any activity occurring anywhere in the lab that poses an eye hazard. This law would include wearing goggles for boiling water or mixing chemicals.

The American National Standards Institute has established criteria for the eye protection, which is mandated by OSHA. Acceptable goggles bear the logo "ANSI Z87" on both the frame and the lens. Face shields will also display this logo. These goggles are available from many suppliers at a small cost. It is the teacher's responsibility to enforce the use of goggles for eye protection.

Students should be instructed at the beginning of the course that they will periodically be required to wear such equipment. Instruction should be repeated each time students are expected to wear eye protection. Students who refuse to wear protective goggles should be removed from the classroom.

There is some controversy concerning the wearing of contact lenses in the science laboratory. Opponents argue that the contact lenses will exacerbate a chemical spill or aerosol fumes and will cause damage to the eye. Proponents argue that the physical presence of the contact lens will help protect the cornea.

The American Academy of Ophthalmology states that one should analyze the hazards in the workplace and determine on an individual basis whether or not it is advisable for someone to wear contact lenses. Gerlovich (1985), p 137, states the Academy's complete position statement on the use of contact lenses in "industrial settings."

Regardless of the decision that is made, the teacher should know which students are wearing contact lenses. A notation might be made in the grade book or seating chart next to the student's name. The teacher will also want written authorization from the student's eye care professional stating that the student should be allowed to wear contact lenses in the laboratory.

The teacher should be advised of any allergies, sensitivities, or medical conditions a student may have to facilitate optimum safety precautions may be observed for the student, This would include allergies, medicines taken whose effects may be modified by chemical exposure, seizure disorders, and pregnancy. These conditions along with any other relevant medical information can be noted on the Student Safety Contract or Student Information Profile.

Work Space

The National Science Teacher's Association (NSTA) recommends that each student be allowed a minimum of 35 square feet of workspace. Overcrowding is especially dangerous in science labs. NSTA also recommends that there should be no more than 24 students engaged in a laboratory activity per teacher per laboratory room.

Modifications for handicapped students may include space for an aide. Certain procedures and expectations of the handicapped student may also need to be made by the teacher.

Student Assistants

Student assistants require special safety precautions. Select them carefully, based on their sense of responsibility, knowledge of the subject, and prior demonstration of consistent adherence to safety practices in the laboratory. They should have completed the class in which they act as assistants and will be trained in laboratory safety procedures. Virkus (1978) pp 51-52 contains guidelines for training laboratory assistants.

Personal Hygiene and Protective Clothing Requirements

- Do not apply cosmetics, eat, drink, smoke, or chew gum in the laboratory.
- Wash hands before leaving the laboratory or after any chemical exposure.

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- Do not smell chemicals directly. Waft the odors to your nose using your hand.
- Appropriate eye protection must be worn, either goggles or a face shield as needed.
- Gloves should be appropriate for the chemicals being used.
- Wear a full-length apron or lab coat.
- Do not wear sandals or open-toed shoes of any kind in the laboratory.
- Do not wear baggy shirts or sweaters, dangly jewelry, neckties, or scarves.
- Tie back long hair.
- Wear a watchstrap that is not absorbent.

Specific Considerations for the Biological Sciences

Included in this section:

- Laboratory and Classroom Management and Student Load
- Animals
- Dissection
- Plants
- Microscopy
- Microbes
- Body Fluids

Laboratory and Classroom Management and Student Load

The National Association of Biology Teachers *Position Statement on the Role of Laboratory and Field Instruction in Biology Education* states, with respect to the following issues:

Class size and supervision.

A student-to-instructor ratio in the biology laboratory classroom must permit safe and effective instruction. Class size should be determined by the physical design of the classroom and should not exceed 24 students in a laboratory setting for any reason when students are assigned to a single teacher.

Teaching load.

Due to the extra time and preparation that laboratory courses require, life science teachers should not be assigned more than five classes per semester. Since each laboratory requires a different repertoire of organisms, equipment, materials, supplies, solutions and planning, and also demands lessons plans and grading time, teaching load should not be more than two process-oriented science course preparations and have no more than 24 students assigned to each class. Teachers should have their own science classrooms and have access to those classrooms during their preparation times. Time must also be allowed within the teaching day for the setup and dismantling of laboratory preparations. Where possible, student or adult laboratory assistance should be provided, and in high school, we strongly recommend that a laboratory manager (or instructional aid) be hired to assist in preparation, setup, and dismantling of laboratory materials for experiential learning lessons.

Animals

Animal study is an indispensable part of any biology curriculum. It facilitates the study of evolution, ecological relationships, animal behavior, taxonomy, anatomy, physiology, and development. Animal study gives meaning to human development and function, as well as fostering students' awe and respect for living things.

Any lab or classroom setting involving animals requires careful planning. Basic safety precautions the teacher must be aware of before using animals in the lab:

- Animals should be obtained form a reliable biological supply house.
- Potential danger exists with wild animals brought in that have been injured or diseased.
- Animal weaknesses may be due to an undetected illness
- Animal diseases may include ringworm, rabies, or rabbit fever.
- Wild animals may carry a variety of vectors (e.g. fleas that carry worms which can be inhaled or swallowed by students; ticks or mites can fall onto the clothing or skin of a student)
- Poisonous animals should never be included in live biology studies by high school students.

Experiments involving the sacrifice of animals are not permitted in the school district. The study of microorganisms and invertebrates, or a computer simulation is preferred. It is important that a qualified adult supervise the handling and humane treatment of animals. Animals are not to be subjected to any discomfort or pain, nor are they to be subject to inhumane treatment by student handlers. Hypodermic needle injection is permissible by a trained person, but surgery on any lab animal or the use of any drug or substance (including alcohol) that can cause adverse effects on the animal is not permitted.

The professional mandate stated in a position paper by the National Association of Biology Teachers (NABT) is excerpted below. It is taken from the "NABT Guidelines for the Use of Live Animals at the Pre-University Level." The article may be found in its entirety in Gerlovich (1985) pp. 150-153.

> Living things are the subjects of biology and their direct study is an appropriate and necessary part of biology teaching. Textbook instruction alone cannot provide students with a basic understanding of life and life processes. We further recognize the importance of research to understanding life processes and providing information on health, disease, medical care, and agriculture.
>
> The abuse of and living organism for experimentation or and other purpose is intolerable in any segment of society. Because biology deals specifically with living things, professional biology educators must be especially cognizant of their responsibility to prevent inhumane treatment to living organisms in the name of science and nature. This responsibility should extend beyond the confines of the teacher's classroom to the rest of the school and the community.

The National Association of Biology Teachers, in speaking to the dilemma of providing a sound biological education at the secondary level, while addressing the problem of humane experimentation, presents the following guidelines on the use of live animals at the pre-university level:

- Biological experimentation should lead to and be consistent with respect for life and all living things.
- Humane treatment and care of animals should be an integral part of any lesson, which includes living animals.
- All aspects of exercises and of experiments dealing with living things must be within the comprehension and capabilities of the students involved.
- Lowest orders of life, such as bacteria and fungi, protozoans and insects, can reveal much basic biological information and are preferable subjects for invasive studies whenever and wherever possible.
- Vertebrate animals can be used as experimental organisms in the following situations:
    - Observations of normal living patterns of wild animals in the free living states of zoological parks, etc,
    - Observations of normal living patterns of pets, fish, or domestic animals.

    - Observations of biological phenomena (i.e., inducing ovulation in frogs through hormone injections that do not cause discomfort or adverse effects to the animals.)
- Animals should be properly cared for:
    - Appropriate quarters for the animals being used should be provided in a place free from undue stress.
    - Animal quarters should provide for sanitation, protection from the elements, and have sufficient space for normal behavioral and postural requirements.
    - Proper food and clean drinking water for those animals requiring water should be available at all times in suitable containers.
    - No animals should be subjected to over handling. Instruct students on the proper handling techniques and limit the amount of handling (one hour maximum per day.) Students should always wash their hands after handling any animal.
    - All animals can bite. Leather gloves should be worn any time animals are handled.
    - If a student is bitten, wash the bite with soup and water and have it checked by a medical specialist. Observe the animal for several days for indications of distress or disease.
    - If an animal dies unexpectedly, a veterinarian should examine it to ascertain that a disease communicable to humans was not involved.
    - A veterinarian should examine ill animals.
    - Animals such as snakes and turtles can carry salmonella and can transmit this so students through contact with fecal material. It is recommended that these animals not be used unless they test negative for salmonella on a routine 3-4 month basis.

- All animal studies should be carried out under the direct supervision of a competent science teacher.
- Students should not be allowed to take animals home to carry out experimental studies.
- There should be no experimental procedures that would subject animals to pain or distinct discomfort.
- Experimental procedures should not involve:
    - The use of microorganisms pathogenic to animals
    - Ionizing radiation, carcinogens, drugs, or chemicals at toxic levels
    - Drugs knows to produce adverse or teratogenic effects
    - Pain-causing drugs
    - Alcohol in any form
    - Electric shock
    - Exercise until exhaustion
- If euthanasia is necessary, an adult who is experienced in such procedures will sacrifice animals in an approved, humane manner.
- Students should not perform surgery on living vertebrate animals.
- Behavioral studies should use only positive reinforcement.
- Egg embryos subject to experimental manipulation must be destroyed humanely at least two days prior to hatching.
- Only a qualified science teacher should carry out administration of anesthetics.
- The following is a partial list of organisms used to cause harmful reactions when handled carelessly (Virkus, 1978)

Ants	Cottonmouth Snake	Pussmoth (Saddleback Caterpillar
Bedbugs	Fleas	Potato Beetle
Black Widow Spider	Gnats	Rattlesnake
Blister Beetle	Ioa Caterpillar	Wasp
Brown Recluse Spider	Jellyfish	Yellow Jacket

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Chiggers	Millipede	
Clams*	Mosquitoes	
Copperhead Snake	Nettling (Slug) Caterpillar	
Coral Snake	Oysters*	

*When living in polluted water or feeding on certain dinoflagelate

Dissection

- Preserving agents usually consist of 10% solution of formalin (40% solution of formaldehyde gas in water) or dry pack chemicals, which present inherent safety issues in the lab when dissecting. Avoid contact with preservatives and instruct students in the proper handling procedures of such specimens.
- Teachers and students should be aware of the possible health hazards, such as cuts, reactions to preservatives (fainting/dizziness, allergic responses), and injury from wearing contact lenses.
- Insure proper room ventilation.
- Chemical splash goggles and protective aprons should be worn during all dissections.
- Wearing rubber or surgical gloves may be recommended especially for students with known skin sensitivities.
- Remind students of the location and use of the eyewash station.
- Remind students to report all accidents no matter how seemingly minor, especially a splash to the eyes or a skin puncture.
- Use only properly sharp instruments for making incisions and cuts.
- Razor blades used for making incisions should be only single-edged.
- Instruct students to:
  - Secure the specimen to the dissecting pan
  - Cut away from the body of the specimen
  - Make all cutting motions away from the student's body and in a direction away from other students as well.
  - Hold probes in the hand opposite the hand used for cutting.
  - Wash hands and tools in warm soapy water at the conclusion of each lab period.
- Preserved specimens should be stored in a cool place inaccessible to students in sealed, labeled, and dated metal or plastic containers. The type of preservative and its concentration should also be labeled on the outside of the container.
- All dissected parts should remain in the dissecting tray until they are disposed of.
- No part of any dissected specimens should ever be ingested or leave the lab room.

Plants

Another major portion of the biology curriculum involves the study of or the use off plants. Some plants may exhibit a range of undesirable characteristics such as poisonous oils, compounds, or thorns. More than 700 species of plants are known to cause adverse reactions in humans, from slight irritation to death. The use of plants requires the observation of the following safety precautions:

- Give students specific instructions in using specific kinds of plants.
- Students should wash their hands after handling plants. They should also be advised to keep both plants and hands away from direct contact with their faces.
- Teachers should be cognizant of any of the following signs of plant poisoning in any student:
  - Constriction of the pupils
  - Increase in nasal and salivary secretions
  - Sweating
  - Gastrointestinal disturbance

- Tightness in the chest
- Muscle tremor
- Blueness around the lips and under the fingernails
- Indications of convulsions

- If plant poisoning is suspected, first aid measures should be taken and the Poison Control Center alerted.
- Parts of the plants on the following lists may threaten the safety of students and teachers. Gerlovich (1985), pp. 148-149 and Virkus (1978), pp 84-86 describe specific dangers.

House Plants	Ornamental plants	Flower Garden Plants
Hyacinth	Daphne	Larkspur
Narcissus	Wisteria	Monkshood
Daffodil	Golden chain	Autumn crocus
Oleander	Laurel	Star of Bethlehem
Diffenbachia	Rhodedendron	Lily of the Valley
Rosary pea	Azalea	Iris
Castor bean	Jessamine	Foxglove
Poinsettia*	Red sage	Bleeding Heart
		Rhubabrb
		Potato

Wooded or Field Plants	Trees and Shrubs	Swamp or Moist Area Plants
Jack-in-the-Pulpit	Wild and Cultivated cherries	Water Hemlock
Moonseed	Oaks	Nightshade
May apple	Elderberry	Jimson weed
Dutchman's breeches	Black Locust	
Buttercup	Buckeye	
Death camas	Yew	
Poison hemlock	Hemlock	
	Holly	

*can cause stomach upset and rash in the mouth but does not cause serious harm.

If collections are desired, review safety precautions with respect to the listed plants and local collecting areas and the dangers that may exist.

- Wild mushrooms should never be ingested.
- Do not touch any parts of a plant of unknown identity.

Microbes

- Instruct students in the proper use of a microscope. Safety factors include:

- Carry the microscope with one hand on the arm and the other hand under the base.
- Always lower the lens as you watch from the side. Only raise the lens to focus when your eye is over the eyepiece.
- Never use pathogenic organisms.
- Take into account the impact that concentrated cultures of relatively innocuous bacteria and viruses could have when inexperienced students are working with them.
- If cultures are to be passed around the room, seal the Petrie dishes with clear tape.
- Inoculating loops must be used with care:
    - The film held by a loop may break and scatter into the air.
    - When a hot loop is inserted into liquid splattering may occur.
    - Placing a contaminated loop into a flame may "aerosol" the organisms before they are killed.
- Avoid the inhalation of air containing high amounts of bacteria or fungal spores. Do not sniff cultures.
- Use Lysol (3 pints water to 1 pt Lysol concentrates) or Clorox (1 pint Clorox: 10 pts water) as a disinfectant.
- Always dispose of microorganisms cultures by first sterilizing at 15 PSI for 15 minutes prior to disposal.

Body Fluids

The use of human body fluids such as blood, saliva, urine, or body cells in a science classroom is discouraged. If labs such as these are undertaken, make sure extraction instruments are used only once and that a safe, secure method of disposal of these instruments is implemented.
Blood: Blood: typing/microscopic examinations of fresh blood are not permitted. Products that simulate ABO and Rh antigen-antibody reaction are available from science supply companies.

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Chemistry Safety Issues

Included in this section:

- Chemical Storage: General
    - Compressed Gases
    - Corrosives
    - Procedures for Handling Extremely Hazardous Chemicals
- Purchase, Use, and Disposal of Chemicals
- Inspection of Facilities
- Special Note: Disposal of Wastes in Sanitary Sewers
- Chemical Spills
- Safety Procedures in the Chemistry Lab
- Safety in the Chemistry Lab

Chemical Storage

Each building should have only one common storage area for chemicals under the supervision of a qualified person. The chemical storage room should be locked and have the following features:

- Approved fire extinguishers and cans of sand and soda positioned near an escape route.
- Spill control and clean-up materials.
- Master control shut-off valves for gas, water, and electricity
- Approved eyewash.
- Safety shower.
- Smoke detectors.
- Acid cabinet
- Nitric acid must be stored separately
- Flammables cabinet
- Separate cabinet for corrosive materials.
- Forced ventilation from floor to ceiling with exhaust hood above roof level, capable of at least 4 air changes per hour with the exhaust isolated from all other building ventilation systems..
- Lip-edged wooden shelving secured to wall with top shelf below eye level.
- A communication system to the main office or emergency center.
- Chemicals should be stored by families as per Appendix D
- Every chemical, including solutions, will be labeled with the name, concentration if applicable, the date purchased or prepared, preparer's initials, and any hazards as per the document Labeling Chemicals in Appendix D.
- Store acids in the Styrofoam shipping containers until needed.
- Store corrosives and other chemicals in the protective shipping materials until needed.
- DO NOT chemicals alphabetically by name as it allows chemicals that may react violently with one another to be stored in close proximity.
- Store the minimum amount of chemical needed for the school year.
- Do not store chemicals on the floor unless they are in containers untended for that purpose.
- Avoid exposing chemicals to heat or bright sunlight..

Chemicals should be stored by families according to the method explained in the Flinn Catalog Reference Manual. Chemicals are stored by families in the broad categories of ORGANIC and INORGANIC groupings. Each is further subdivided into families of compatible chemicals as listed below:

INORGANIC	ORGANIC
1. Metals, hydrides	1. Acids, anhydrides, peracids
2. Halides, sulfates, sulfites, thiosulfates	2. Alcohols, glycols, amines, imines
3. Amides, *nitrates, *nitrites, nitric acid	3. Hydrocarbons, esters, aldehydes
4. Hydroxides, oxides, silicates, carbonates, carbon	4. Ethers*, ketones, ketenes, halogenated hydrocarbons, carbon ethylene oxide
5. Sulfides, selenides, phosphides, carbides, nitrides	5. Epoxy compounds, isocyanates
6. Hypochlorites, and hydrogen peroxides	6. Peroxides, hydroperoxides, azides*
7. Borates, chromates, manganates, permanganates	7. Sulfur
8. Acids (except nitric)	8. Phenols, creosols
9. Sulfur, phosphorous*, arsenic, phosphorous pentoxide	

* potentially unstable

Storage and Handling of Compressed Gases

- Always handle as high-energy sources.
- Protect the cylinder valve when handling.
- Do not expose to heat. The pressure inside increases by 5 PSI per degree Fahrenheit.
- Do not lubricate, modify, or in any way tamper with a cylinder valve.
- Use cylinders of toxic, reactive or flammable gases only under a fume hood.
- Shut off a gas source before attempting to extinguish a fire. The gas can re-ignite, causing an explosion.
- Secure gas cylinders in place so that the cylinder does not fall, damaging the valve.

Storage and Handling of Corrosives

- Store corrosives in appropriate corrosives cabinet.
- Store corrosives in the original packing material until just prior to use.
- Use a face shield when handling corrosive materials.
- Inspect all shelves and shelf clips and brackets every 3 months to check for possible corrosion.

Extremely Hazardous Materials

- Use a fume hood when the PEL is less than 50 ppm as noted on the MSDS
- Use carcinogens, mutagens, and teratogens only under a fume hood.
- Keep flammable liquids away from heat, possible sources of sparks, or open flames.
- Use extreme caution when using finely separated materials (metal dust.) as they may form explosive mixtures with air.
- Store sodium, potassium, and other water-reactive materials under dry oil. Use and store them in very small quantities.
- Glycerin should be available only to teachers.
- Do not store opened cans of ethyl ether past expiration date. If possible, purchase in containers of the size that will be used immediately.

Flinn Catalog Reference Manual shows shelf layout and storage pattern (Appendix D). Consult local fire codes for information on storing flammables.

Inspection of Facilities:

The Fire Marshall will walk through the buildings at least once per year and will be given an updated copy of all chemicals on inventory at that time.

The Laboratory Standard states that all equipment must be in good working order at all times. Some equipment is required and other equipment is suggested; however if a piece of equipment is present it must be in working order at all times. This applies to ALL equipment, whether required or suggested. Each teacher will check his or her area using the checklist in Appendix C and file copies with the department chair and the principal. This checklist documents the following areas and the frequency with which each area must be checked:

- Goggles must be clean and functional.
- Laboratory ventilation must meet the standard of eight air changes per hour and must be tested quarterly.
- A respirator must be fit tested and appropriate cartridges must be available.
- Fire extinguishers must be Tri-Class ABC and must be properly inspected.
- Eyewashes must be clean, functional, and flushed once a month.
- Fume hoods must be operational at the level of 70-100 linear feet per minute as measured by a velometer.

Any safety equipment reported to be out of order at any time must be repaired immediately as this is a serious violation of the Laboratory Standard.

Purchase, Use, and Disposal of Chemicals

- Purchase in class-size quantities only, for the school year
- Label all chemicals accurately with date of receipt or preparation, initials of preparer, and storage/use information.
- Dispose of unused portions according to the Flinn Disposal Guide in the Flinn Catalog Reference.
- Properly store flammable liquids in small quantities in containers with a provision for bonding and receiving vessels when the liquid is transferred.
- Read and understand the label before opening a package.
- Incoming chemicals should be received and opened by a trained science teacher who will file the MSDS and retain packing material that is needed for safe storage of the chemical.
- Read the MSDS before using a chemical.

To dispose of unwanted or waste chemicals:

- Prepare a list of chemicals you wish to dispose of.
- Classify each into a hazardous or non-hazardous waste category.
- Unlabeled chemicals must be identified to the point of placing them in hazardous or non-hazardous categories.

Disposal of Wastes in Sanitary Sewers

- Small quantities of some wastes can be disposed of in sanitary (not storm) sewers although this is discouraged. Less than a few hundred grams can be flushed with lots of water to dilute.

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- Inorganic salts in which both the cation and anion are relatively nontoxic are permissible for drain disposal if they are soluble to a degree of a few percent. Check local regulations for possible restrictions. Mineral acids or bases should be neutralized before drain disposal.
- Some organic compounds that are reasonably soluble in water are suitable for drain disposal. Check local regulations. Generally, short chain alcohols, amides, carboxylic acids, esters, and ketones are suitable. One exception would be low boiling point flammable liquids such as diethyl ether. Other exceptions include explosives like azides or peroxides.

Chemical Spills

Most spills can be avoided by correct handling of chemical containers. They do occur occasionally and the following supplies should be on hand and readily available for clean-up of items still in the storeroom that require special attention::

- Neutralizing agents, such as sodium bicarbonate.
- Absorbants, such as sand and vermiculite
- Paper towels.
- Sponges
- Mop and bucket.
- Broom and dustpan.
- Safety goggles.
- Apron.
- Plastic garbage bags.
- Mercury sponge.
- Seamless polyethylene bottle for mercury spills.

If a spill should occur:

- Attend to any person needing decontamination
- Notify others to stay clear of the spill.
- Avoid breathing vapor if it is a liquid spill. Open windows; turn on exhaust fans.
- Evacuate classroom.
- Wear appropriate clothing and clean up the spill.
- Use MSDS, Flinn Catalog, or Emergency Response Guide for more information.

Solid spills of less toxic materials can be swept up with just broom and dustpan, and material sealed in plastic bag before placing in the trash.

Liquid spills require rubber gloves and the following procedures:

- Inorganic acids or bases must be neutralized with soda ash, baking soda, or vinegar. Use sand, vermiculite, or paper towels depending on the size of the spill. Students should not be working with large enough quantities of a chemical to require more than a few paper towels for cleanup.
- Liquids splash on items quite a distance away. Inspect and treat all areas.
- Mop up the spill.
- Dispose of residues according to disposal procedures for that particular chemical.
- Mercury spills present an especially hazardous situation. There should no longer be mercury of any type in buildings in the St. Marys City Schools. The procedure is included here only for special emergencies.
  - Provide immediate ventilation by opening doors and windows and turning on exhaust fan.

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- Do not sweep the mercury with a broom as this increases the surface area of mercury in contact with the air. Instead, attempt to contain the mercury and the free mercury vapor. Push the pools of mercury together with a sheet of paper.
- Avoid contaminating other items. Place plastic bags over your shoes if you must walk in the spill area.
- Pick up the pools with a closed suction device such as a dropper pipette. Transfer droplets to a seamless polyethylene bottle. When the pickup is completed, place the dropper inside the bottle and seal.

- Remaining hidden droplets should be treated as follows:
  - Zinc powder should be spread over the area. It will form an inert amalgam with the mercury and this can be collected for disposal just as elemental mercury.
  - Wipe the area with a mercury sponge containing a large surface area in the form of zinc fibers. An amalgam will form if the mercury is clean.
  - Rent a mercury vacuum cleaner from Flinn Scientific. DO NOT use an ordinary vacuum as it will create an aerosol of the remaining mercury.
- Eliminate mercury of all kinds from the k-12 school.

Safety Equipment in the K-12 School Laboratory

Following is a brief description of safety equipment that should be included in any laboratory or classroom area in which students handle science materials:

Eye Protection: The State of Ohio requires each student to wear personal eye protection. The material should conform to America National Standard Institute (ANSI) Z87.1-1979 standards for use, durability, and cleaning. Appropriate chemical resistant goggles are available through Flinn Scientific or other suppliers.

Eyewash stations should be made available with signs posted in the lab identifying their location. All students should be instructed in the use of eyewash stations.

Fire Extinguishers: Best for classrooms are one rated A, B, and C fires such as a carbon dioxide or dry powder unit. Fire extinguishers must be recharged regularly and replaced in the same position in the lab. Instruct students in the use of a fire extinguisher at the beginning of each school year.

First Aid Kits: Kits should be available in lab with the location clearly marked and identified. Inventory the kit regularly and instruct students in their use and contents.

Other Items: Safety showers, safety signs, posters, bottle carriers, storage and disposal cans, and labels. Instruct students in the location/use of these items.

Safety in the Chemistry Lab

The Facility:

Do an annual formal inspection (see Appendix C), noting and structural abnormality or unsafe condition in the classroom, storeroom, or laboratory and report it in writing to the administration.

Chemistry classrooms and laboratories should be used for chemistry or laboratory science classes only.

Equipment Considerations:

- Broken glassware is to be disposed of in a separate clearly marked container. This protects janitors and anyone rummaging through a trashcan from being cut.
- All cut edges of glassware should be fire polished.
- Do not allow students to insert glass tubing. Teachers should do this procedure. Lubricate tubing with glycerin, wrap in a towel, and twist gently into a hole of proper size.
- Turn water on gently to avoid splashing materials from glassware.

- Check charge level of fire extinguishers and recharge as needed. Return to same location.
- Maintain emergency lighting if there is no outside source or if the facility is used at night.
- Maintain a file of operating instructions/manuals for all equipment.
- Check for stability of glassware support when assembling any apparatus.

Chemicals: Responsibilities of the Teacher:

- All storage containers should be labeled with the following information: Chemical name, formula, concentration and solvent if in solution, hazard warnings if applicable, name or initials of person who did the transfer.
- If procedure involves noxious odors, flammable or toxic gases, use the fume hood.
- Carry containers of chemicals with two hands, never by the lid.
- Maintain the smallest possible amount of chemicals for projects throughout the year.
- Do not allow horseplay in the lab. Maintain control of student behavior.
- Instruct students in the use of all safety equipment in the lab.
- All safety equipment should be identified with a sign.
- Group sizes should be assigned considering the number of students who can safely perform an experiment.
- Plan sufficient time to perform the procedure and clean up.
- Develop safety lesson plans with measurable objectives.
- Develop an accident plan and instruct students in its implementation.
- Instruct students never to eat or drink in the laboratory.
- Turn off all gas valves at the end of lab. Turn off the master gas valve at the end of the day.
- Place all chemicals in the storeroom and lock the storeroom at all times.
- Do not leave students unsupervised.
- Lock the lab when not in use.
- Goggles must be worn by all present when glassware, chemicals, of heat is in use.
- Full-length lab coats or aprons should be worn when appropriate.
- Gloves appropriate to withstand the hazards of the chemical in use should be work when appropriate.
- Store chemicals in approved containers and storage devices.
- Do not smoke in any area where chemicals are stored or used.
- Weight the educational value of a lab against its potential risk for students.
- Periodically inventory lab safety devices and make a written report of defective devices to the administration on the form in Appendix C.
- Note any structural abnormality or unsafe condition and report it to the administration on the form in Appendix C.
- Observe students for any abnormal physical or mental activity before, during, or after an experiment. Do not allow any student who displays abnormal physiological characteristics to perform an experiment.
- Develop a plan to secure the lab during emergency drills.
- Potential hazards should be identified and pointed out to students before an experiment is performed.
- Include a list of safety rules with lesson plans for a substitute. It is not advisable for a sup to monitor a lab activity.
- Document safety violations and report safety concerns in writing to the administration using the form in Appendix C.
- Always store chemicals with labels to the front in a readable position.
- Use a grease or wax pencil for labeling laboratory glassware.

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- Report missing or stolen materials to the administration immediately.

Chemicals: Student Responsibility

- Report all accidents to the instructor, no matter how seemingly small.
- Never mix chemicals without an approved, defined procedure.
- Never drink or eat from any laboratory glassware.
- Never point the open end of a test tube at yourself or at other students.
- Never smell the contents of a test tube unless instructed to do so as a part of the experiment. When so instructed, never bring the container directly to your nose. But waft the chemical by waving your hand over the test tube and bringing the air towards your nose.
- Work areas should be uncluttered and free of combustible materials.
- Never touch any part of your face while working in lab.
- Never taste a chemical in lab.
- Wash your hands at the end of each experiment.
- Glassware and equipment should never be placed at the edge of a tabletop or work space.
- Never leave chemical experiments while in progress.
- It is advisable that contact lenses not be worn during an experiment without the teacher's knowledge.
- Long hair should be pulled back and fastened out of the way during labs.
- Perform only authorized experiments assigned by the instructor.
- Inform the instructor of any breakage, spills, or contamination at once.
- Sinks are not to be used to dispose of matches, paper, wire, sand, metal, or any other insoluble material.
- Do not wear bulky jewelry when working in lab.
- Always read the MSDS and labels before handling any chemical.
- If instructions seem unclear, always ask your instructor for clarification before working.

General Do's and Don'ts:

- Allow falling objects to fall. Never try to grab a falling object.
- Allow hot glassware to cool by placing it on a special surface. Do not submerge hot glassware in water.
- Assume any glassware placed on a surface designated for cooling is hot; do not touch. Bring palm close to glassware to check for radiant heat.
- Always pour acid into water. Do not pour water into acid.
- Never pipette with your mouth. Use a bulb or an automatic filler.
- Asbestos of any type will not be used in the lab.
- Students will never be giver chemicals to take home.
- Teachers will not accept unsolicited donations of chemicals without approval of the department chair.

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Physics Safety Issues

The physics facility may look like the set of a new Star Trek movie or it may more closely resemble the laboratories of 15th century alchemists. In either case, the physics teacher faces the challenge of capturing the attention of your students and guiding them safely through the study of physics. The unique safety challenges to be met will be largely determined by the equipment present and the conditions under which the students are to work.

Safety is a learned behavior and is to be incorporated into every lesson plan. The physics teacher is to be aware of all safety issues and concerns by conducting experiments and demonstrations prior to their use in the classroom. Dangerous situations develop quickly and the teacher must possess the knowledge and preparedness to deal immediately and safely with any situation that may occur.

Assess the classroom/laboratory for safety and document your findings on the form in Appendix C. Use a safety contract with your students. Samples are found in Appendix C, or you may design or modify a contract to meet your needs.

Physics Topics addressed in this section:
Electricity
Energy
Heat
Pressure
Light
Lasers
Sound
Radiation
Radioactivity

Related Safety Concerns:

- Electricity
- Know the location of the master cut-off switch
- Low voltage DC should be used for the study of simple circuits
- All student circuits should be checked by the teacher before the power is turned on
- Never touch electrical circuit components with the power on. Use only insulated tools to make those checks.
- Insert the plug LAST and remove it FIRST.
- Only one hand at a time should contact equipment when using electrical current to avoid both hands contacting live wire.
- Check electrical batteries for leakage periodically. Do not leave them in appliances for long periods of time.
- Permanently insulate any metal object used near an electrical current. Do not allow live wires to contact grounded metal objects.
- Do not contact the fine spray from the charging of a chemical storage battery.
- Handle storage batteries carefully as although their voltage is low, it can produce a high current when short-circuited.
- Label switches for “on” and “off” positions.
- The teacher should check the grounding on equipment before it is used.
- Do not use equipment with frayed cords or other visible defects.
- Have equipment repaired by a qualified person.

- Do not pull plugs out by holding onto the wire. Hold the plug.
- Keep liquids away from electrical outlets to reduce the possibility of spills.
- The teacher should check all potentiometers before students use them.

To extinguish an electrical fire, first pull the plug, then extinguish with a Class C dry chemical carbon dioxide fire extinguisher.

Motion and Forces

- Devices that are to be stationary are to be secured with a C-clamp.
- Use spring-loaded carts and heavy masses only as directed.
- Goggles should be worn for centripetal force labs. Caution students to stay in their workspace and out of the path of spinning masses. The teacher should check to be sure each mass is securely fastened.
- Use Exacto knives carefully when building bridges.
- Protective eyewear must be worn when breaking bridges.
- Solar eclipses should be viewed only indirectly.
- Model Rockets fall under the safety code of the National Association of Rocketry (NAR) and their safety code should be followed. Use only factory-prepared solid engine propellant, as recommended by the manufacturer. The teacher will provide direct supervision.

Energy

- Secure ring stands with a C-clamp.
- Use springs only within their elastic limits.
- Wear goggles when viewing the pointer on a fixed scale.
- Allow sufficient space for activities involving collisions.

Heat

- Leave the master gas cut-off valve OFF when not in use.
- Never heat a closed container.
- Students should not insert glass thermometers into rubber stoppers. Use metal computer interface probes if the teacher is not preparing the stopper-thermometer apparatus.
- Wear goggles and insulated gloves when using cryogenic fluids.
- Check the operation of Bunsen burners periodically.
- Use fire retardant pads and gloves when handling hot materials.
- Only Pyrex glassware should be used when heating liquids.
- Always close gas jets.
- Mercury spills should be cleaned up as directed in the Chemistry section.
- Fire extinguisher and fire blanket should be easily accessible.

Pressure

- Do not allow the pressure in a pressure cooker to exceed 20 PSI. Allow the cooker to cool completely to room temperature before opening it.
- Mercury manometers will not be used.

Light

- Tape the edges of sharp-edged mirrors.
- Discard broken mirrors.

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- Instruct students in the care that must be taken when using mirrors and prisms in direct sunlight.
- Use ultraviolet light sources (mercury vapor lamps, carbon arc lamps) cautiously as they can damage the retina.
- Do not exceed the elastic limits of large coil springs or slinkys when used to study wave properties.
- Set up ripple tanks so that the light source, motor, and electrical source are stable.
- Check spectroscope high voltage supplies before using them in the classroom. Do not touch the ends of the spectrum tube when it is in use.
- Strobe lights may cause physiological or psychological reactions to the effects of a strobe light. (students with seizure disorder.)

Sound

- Use a high-speed siren only at moderate speeds. Fasten it securely to the desk.
- Do not touch the top of a glass tube with a tuning fork. Tape the tops of such tubes.
- The production of sound levels greater than 110 decibels can damage hearing.

Lasers

- Do not permit eye exposure to either direct or reflected laser light.
- Make targets from non-reflecting material.
- Do not set beams at eye level.
- Students should not move around the room during the activity.
- Operate the laser at the lowest possible power.
- Maintain the room's illumination bright enough so that the pupils of the eye remain small.
- Set up prisms before the students arrive to avoid unexpected reflections.
- Use beam stops to terminate the laser beam when needed.
- The .5-milliwatt Helium-Neon laser is adequate for high school use.
- Approved laser goggles are recommended for teacher and students.

Radiation

- Be fully aware of the hazards and cumulative effects of radiation emitting devices if you choose to use them.
- Use proper shielding when using an apparatus that generates X-rays, such as the heat effect tube, magnetic or deflection tube, and the shadow or fluorescence tube. Only the teacher should use these tubes for demonstration purposes.
- Examine vacuum tubes and replace if brittle as brittle tubes are prone to explosion.
- Cathode ray tubes should be encased in a frame and only the teacher should transport them.
- Use the lowest voltage possible and have students view tubes from a minimum distance of eight feet.

Radioactivity

- The teacher must be properly trained in the use of radioactive materials.
- Follow limits set by the Nuclear Regulatory Commission (NRC) on the quantity of radioactive materials that may be kept without a license for instructional use.
- Handle all radioactive materials with tongs of gloves.
- Students may handle radioactive materials only with specific instruction given by the teacher.
- Do no permit students to work with radioactive isotopes for an extended period of time.
- The exposure to radiation is reduced to one-fourth as you double your distance from the source.

- Proper shielding can reduce radiation effectively.
- The “window” area of the tube in a device used to measure radiation is very delicate and must be handles carefully.
- Radioactive materials may be disposed of only as designated by the rules and regulations of the NRC.

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Employee Training

Chemical Labeling

The Hazard Communication Standard (Right-to-know law), implemented in1983 by OSHA, gives teachers, students and parents the right to know about the hazards associated with the chemicals used in the classroom/laboratory. The standard requires the use of Materials Safety Data Sheets (MSDS) and labels to communicate safety information to customers.
The initial guideline for labeling stated that the label must list the "appropriate hazard warnings". In1994, OSHA clarified this, saying that a label must include "the specific physical or health hazard(s) including target organs affected".

OSHA also realized that labels may not be large enough to list every possible warning so they said the label should provide a brief summary of the hazards in a highlighted form. For in-depth information, refer to the Material Safety Data Sheet.

Based on what we now know, how should a chemical container or bottle be labeled? We suggest the best approach to proper chemical container labeling is to list these four items on the label.

1. Chemical name and formula

2. Concentration—for a solution, indicate the solution's molarity.

3. Hazards how the body and particular organs would be affected, worded clearly so that anyone would be able to understand. Information is on MSDS.

4. Date Prepared—some chemicals have a limited shelf life

5. Preparer’s name or initials.

For a 6M hydrochloric acid solution, the label could read:

> Hydrochloric acid
> 6M solution
> Corrosive to all body tissue, especially skin and eyes. Avoid skin contact. 1999

Additional label information may be required in some states, such as the National Fire Protection Association (NFPA) code or the Chemical Abstract Services (CAS) number to be on the label.

Use a permanent marker on a label paper. Print clearly.

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Incident Management

Accident/emergency incidents are of three types:

1. One or more individuals have been injured in some way
2. A situation has developed in which there is potential for bodily harm to one or more individuals
3. One or more individuals have been injured and the potential for further injury exists.

The emergency plan must deal with all three situations. First consideration is to treat injuries and prevent further injury.

1. **Notify**
   Get word to someone who can call for help. Develop a notification system with others in your building and put it in writing.
2. **Evacuate:** Evacuate students as necessary. Get everyone to a safe location. Organize students and arrange supervision if necessary.
3. **Assemble**
   Assemble cleanup workers. Follow approved procedures for containment, cleanup, and disposal.
4. **Report** Report when the incident is controlled and cleanup is complete.

How to Prevent and Respond to Laboratory Chemical Spills

Spill prevention is preferable to spill cleanup. In the event that a chemical spill should occur, this plan will provide the protocol for the safest possible cleanup. An understanding of the chemical, its hazards, and knowledge of the spill containment equipment available is the responsibility of every science teacher.

Spill Prevention

Prevention of spills is far preferable to containment and cleanup. Experiments and laboratories should be designed to minimize the possibility of chemical spills. Experiments should use the minimal amount of chemicals whenever possible. The less chemical available, the smaller the spill. In addition, the least hazardous material possible should be used.

Store and dispense chemicals in unbreakable bottles, such as plastic- or PVC-coated glass bottles, or the secondary containment devices they are shipped in. If a bottle is dropped, secondary containment will contain the spill and may actually prevent the spill from occurring.

Equipment for Spill Containment

Spill control equipment includes fire blankets, spill control materials such as sand, absorbent, neutralizer, and a mercury spill control kit.

A fire blanket made of 100 percent wool is an excellent spill control device. It will contain and control both the spill and its vapors and can be thrown over a spill if no other spill control materials are available. It helps

absorb any liquid, and contain the vapors. Slipping and falling into the spill is a concern as acids and other chemicals spilled on a tile floor can become very slippery. The blanket lessens the risk of slipping and falling into the spill.

The amount of spill containment material on hand will vary from lab to lab but should be large enough to contain a spill from the largest stored bottle in the laboratory, often a 2.5 -liter bottle

Spill control materials should contain at least three components:

1. sand - used to contain a spill, provide traction, and prevent the spill from rapidly spreading across the tile floor.
2. absorbing agent - contains and absorbs the liquid spill so it is easier to clean up, transport, and dispose.
3. neutralizer - for inorganic acid spills is a base such as sodium carbonate or calcium. If strong bases are used in your laboratory, it is wise to keep a supply of citric acid on hand to neutralize the base. A 2.5-kg bottle of citric acid is large enough to neutralize the entire contents of almost any bottle of base.

A plastic broom, plastic dustpan, and several large heavy-duty plastic garbage bags placed near the spill control kit for cleanup and disposal.

Mercury, even in thermometers, is no longer used in St. Marys City Schools. All mercury thermometers should be replaced with alcohol thermometers or computer-based units.
If a mercury clean up is necessary, the procedure outlined in the Chemistry section, page 30. Sprinkling zinc dust on the spill area can also clean up small droplets of mercury. Zinc dust reacts with mercury to form a very stable and safe amalgam that is easy to handle, and safe to dispose of in the trash.

Spill Control Procedures and Training

Contingency plan for spill management:

1. Quickly assess the spill, its hazards, and the danger to yourself and your students. If the spilled chemicals are unknown, assume the worst and evacuate.

2. Notify other laboratory personnel of the accident, and if necessary, evacuate the area. The safety of you and your students is always the top priority.

3. Tend to any injured or contaminated person and if necessary request help. If the chemical is splashed into an eye or onto skin, immediately irrigate using an eyewash or shower. If the chemical is splashed on your clothes, you may have time to first contain the spill with a fire blanket or spill control materials and then treat yourself. Remember, if you use a safety shower near a chemical spill, the water may expand the spill area.

4. Take steps to contain and limit the spill if this can be done without risk of injury or contamination.

5. Clean up the spill using appropriate procedure. Dispose of contaminated materials properly.

6. Call in emergency personnel if at any time your safety or your students' safety is in jeopardy.

To contain and control a chemical spill, the following procedure works well.
1. Gently pour sand around the spill and onto the spill to contain the spill, prevent it from spreading, and provide traction if you need to walk over it.
2. Pour absorbent (kitty litter, oil absorbent) around the spill and onto the spill. This will absorb the liquid and also begin to contain any vapors. For both the absorbent and sand, it is best to gently drop or sprinkle the spill control material around the spill and then onto the spill to avoid further spreading. Lastly, if the spill is an inorganic acid or base, apply the appropriate neutralizer around the spill and onto the spill. The neutralizer needs to be mixed well with the sand and absorbent to come in contact with all of the spilled chemical—use a plastic broom to mix well.

After the spill is controlled, students are evacuated and injuries are addressed, then the cleanup begins. If the material is warm or still giving off vapors, ventilate the room and wait before cleaning up. Use a plastic dustpan and plastic broom to sweep up the now solid mess and place it into large, heavy-duty garbage or leaf bags for disposal. If at any time during the chemical spill containment or cleanup step you don't feel comfortable, leave the area and get help.

Make spill control containment and cleanup part of your annual safety training. Simulate a chemical spill with water and use sand as the control material. Note how quickly the "spill" spreads. Practice applying the spill control material around and then onto the spill. Determine the most convenient location for storing your spill control materials. Training is one of the most important components of an effective safety program.

Chemical spills will occur in your laboratory. With proper equipment, procedures, and training, many spills can be prevented and the spills that do occur can be handled safely and effectively.

Emergency Evacuation Plan

The building emergency evacuation plan will be formulated by the teachers in each building, taught to students, and posted in a prominent location. It should include the following:

1. Chain of notification from the accident site to the main office.
2. Location of phone and emergency numbers
3. Who will call or seek assistance and how
4. Location of emergency equipment
5. Location of first aid kit

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Appendix A

The Laboratory Standard

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Appendix A

Components of the Chemical Hygiene Plan

I. Standard Operating Procedures
- **A.** General Employee Rules and Procedures
  - a. Safety in the Elementary Classroom
  - b. Middle School
  - c. High School
  - d. Role of the Teacher
  - e. From the Beginning
  - f. Goggles
  - g. Lesson Plans and Activities
- **B.** General Laboratory Rules and Procedures
- **C.** Personal Hygiene Guidelines
- **D**. Protective Clothing Requirements
- **E**. Housekeeping Rules
- **F.** Spill and Accident Procedures
- **G**. Chemical Storage Rules and Procedures
  - **1.** Compressed Gas Handling Instructions
  - **2.** Flammable Chemical Handling Instructions
  - **3.** Corrosive Material Handling Instructions
- **H.** Procedure – Specific Safety Rules and Guidelines (includes severely toxic and carcinogenic substance)
- **I.** Prior Approval Required Procedures
- **J.** Safety Equipment Inspection

II. Employee Training
III. Exposure Evaluations
IV. Medical Evaluations
V. Monitoring
VI. Emergency Evacuation Plan
VII. Reprint of the Laboratory Standard

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The Laboratory Standard

Standard Number: 1910.1450AppA
* Standard Title: National Research Council Recommendations Concerning Chemical Hygiene in Laboratories (Non-Mandatory)
* SubPart Number: Z
* SubPart Title: Toxic and Hazardous Substances

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Foreword
Corresponding Sections of the Standard and This Appendix

A. General Principles
1. Minimize all Chemical Exposures
2. Avoid Underestimation of Risk
3. Provide Adequate Ventilation
4. Institute a Chemical Hygiene Program
5. Observe the PELs and TLVs

B. Responsibilities
1. Chief Executive Officer
2. Supervisor of Administrative Unit
3. Chemical Hygiene Officer
4. Laboratory Supervisor
5. Project Director
6. Laboratory Worker

C. The Laboratory Facility
1. Design
2. Maintenance
3. Usage
4. Ventilation

D. Components of the Chemical Hygiene Plan
1. Basic Rules and Procedures
2. Chemical Procurement, Distribution, and Storage
3. Environmental Monitoring
4. Housekeeping, Maintenance and Inspections
5. Medical Program
6. Personal Protective Apparel and Equipment
7. Records
8. Signs and Labels
9. Spills and Accidents
10. Training and Information
11. Waste Disposal

E. General Procedures for Working With Chemicals
1. General Rules for all Laboratory Work with Chemicals
2. Allergens and Embryotoxins
3. Chemicals of Moderate Chronic or High Acute Toxicity
4. Chemicals of High Chronic Toxicity
5. Animal Work with Chemicals of High Chronic Toxicity

F. Safety Recommendations
G. Material Safety Data Sheets

Foreword

As guidance for each employer's development of an appropriate laboratory Chemical Hygiene Plan, the following non-mandatory recommendations are provided. They were extracted form "Prudent Practices" for Handling Hazardous Chemicals in Laboratories" (referred to below as "Prudent Practices"), which was published in 1981 by the National Research Council and is available from the National Academy Press, 2101 Constitution Ave., NW,. Washington DC 20418.

"Prudent Practices" is cited because of its wide distribution and acceptance and because of its preparation by members of the laboratory community through the sponsorship of the National Research Council. However, none of the recommendations given here will modify any requirements of the laboratory standard. This Appendix merely presents pertinent recommendations from "Prudent Practices", organized into a form convenient for quick reference during operation of a laboratory facility and during development and application of a Chemical Hygiene Plan. Users of this appendix should consult "Prudent Practices" for a more extended presentation and justification for each recommendation.

"Prudent Practices" deal with both safety and chemical hazards while the laboratory standard is concerned primarily with chemical hazards. Therefore, only those recommendations directed primarily toward control of toxic exposures are cited in this appendix, with the term "chemical Hygiene" being substituted for the word "safety". However, since conditions producing or threatening physical injury often pose toxic risks as well, page references concerning major categories of safety hazards in the laboratory are given in section F.

The recommendations from "Prudent Practices" have been paraphrased, combined, or otherwise reorganized, and headings have been added. However, their sense has not been changed.

Corresponding Sections of the Standard and this Appendix

The following table is given for the convenience of those who are developing a Chemical Hygiene Plan, which will satisfy the requirements of paragraph (e) of the standard. It indicates those sections of this appendix, which are most pertinent to each of the sections of paragraph (e) and related paragraphs.

Paragraph and topic in laboratory standard	Relevant appendix section
(e)(3)(i) Standard operating procedures for handling toxic chemicals.	C, D, E
(e)(3)(ii) Criteria to be used for implementation of measures to reduce exposures.	D
(e)(3)(iii) Fume hood performance	C4b
(e)(3)(iv) Employee information and training (including emergency procedures).	D10, D9
(e)(3)(v) Requirements for prior approval of laboratory activities.	E2b, E4b
(e)(3)(vi) Medical consultation and medical examinations.	D5, E4f
(e)(3)(vii) Chemical hygiene responsibilities.	B
(e)(3)(viii) Special precautions for work with particularly hazardous substances.	E2, E3, E4

In this appendix, those recommendations directed primarily at administrators and supervisors are given in sections A-D. Those recommendations of primary concern to employees who are actually handling laboratory chemicals are given in section E. (Reference to page numbers in "Prudent Practices" are given in parentheses.)

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A. General Principles for Work with Laboratory Chemicals

In addition to the more detailed recommendations listed below in sections B-E, "Prudent Practices" expresses certain general principles, including the following:

1. It is prudent to minimize all chemical exposures. Because few laboratory chemicals are without hazards, general precautions for handling all laboratory chemicals should be adopted, rather than specific guidelines for particular chemicals (2,10). Skin contact with chemicals should be avoided as a cardinal rule (198).
2. Avoid underestimation of risk. Even for substances of no known significant hazard, exposure should be minimized; for work with substances, which present special hazards, special precautions should be taken (10, 37, 38). One should assume that any mixture will be more toxic than its most toxic component (30, 103) and that all substances of unknown toxicity are toxic (3, 34).

3. Provide adequate ventilation. The best way to prevent exposure to airborne substances is to prevent their escape into the working atmosphere by use of hoods and other ventilation devices (32, 198).

4. Institute a chemical hygiene program. A mandatory chemical hygiene program designed to minimize exposures is needed; it should be a regular, continuing effort, not merely a standby or short-term activity (6,11). Its recommendations should be followed in academic teaching laboratories as well as by full-time laboratory workers (13).

5. Observe the PELs, TLVs. The Permissible Exposure Limits of OSHA and the Threshold Limit Values of the American Conference of Governmental Industrial Hygienists should not be exceeded (13).

B. Chemical Hygiene Responsibilities

Responsibility for chemical hygiene rests at all levels (6, 11, 21) including the:

1. Chief executive officer, who has ultimate responsibility for chemical hygiene within the institution and must, with other administrators, provide continuing support for institutional chemical hygiene (7, 11).

2. Supervisor of the department or other administrative unit, who is responsible for chemical hygiene in that unit (7).

3. chemical hygiene officer(s), whose appointment is essential (7) and who must:
(a) Work with administrators and other employees to develop and implement appropriate chemical hygiene policies and practices (7);

(b) Monitor procurement, use, and disposal of chemicals used in the lab (8);

(c) See that appropriate audits are maintained (8);

(d) Help project directors develop precautions and adequate facilities (10);

(e) Know the current legal requirements concerning regulated substances (50); and

(f) Seek ways to improve the chemical hygiene program (8, 11).

4. Laboratory supervisor, who has overall responsibility for chemical hygiene in the laboratory (21) including responsibility to:

(a) Ensure that workers know and follow the chemical hygiene rules, that protective equipment is available and in working order, and that appropriate training has been provided (21, 22);

(b) Provide regular, formal chemical hygiene and housekeeping inspections including routine inspections of emergency equipment (21, 171);

(c) Know the current legal requirements concerning regulated substances (50, 231);

(d) Determine the required levels of protective apparel and equipment (156, 160, 162); and

(e) Ensure that facilities and training for use of any material being ordered are adequate (215).

5. Project director or director of other specific operation, who has primary responsibility for chemical hygiene procedures for that operation (7).

6. Laboratory worker, who is responsible for:

(a) Planning and conducting each operation in accordance with the institutional chemical hygiene procedures (7, 21, 22, 230); and

(b) Developing good personal chemical hygiene habits (22).

C. The Laboratory Facility

1. Design. The laboratory facility should have:

(a) An appropriate general ventilation system (see C4 below) with air intakes and exhausts located so as to avoid intake of contaminated air (194);

(b) Adequate, well-ventilated stockrooms/storerooms (218, 219).

(c) Laboratory hoods and sinks (12, 162);

(d) Other safety equipment including eyewash fountains and drench showers (162, 169); and

(e) Arrangements for waste disposal (12, 240).

2. Maintenance. Chemical-hygiene-related equipment (hoods, incinerator, etc.) should undergo continual appraisal and be modified if inadequate (11, 12).

3. Usage. The work conducted (10) and its scale (12) must be appropriate to the physical facilities available and, especially, to the quality of ventilation (13).

4. Ventilation - (a) General laboratory ventilation. This system should: Provide a source of air for breathing and for input to local ventilation devices (199); it should not be relied on for protection from toxic substances released into the laboratory (198); ensure that laboratory air is continually replaced, preventing increase of air concentrations of toxic substances during the working day (194); direct air flow into the laboratory from non-laboratory areas and out to the exterior of the building (194).

(b) Hoods. A laboratory hood with 2.5 linear feet of hood space per person should be provided for every 2 workers if they spend most of their time working with chemicals (199); each hood should have a continuous monitoring device to allow convenient confirmation of adequate hood performance before use (200, 209). If this is not possible, work with substances of unknown toxicity should be avoided (13) or other types of local ventilation devices should be provided (199). See pp. 201-206 for a discussion of hood design, construction, and evaluation.

(c) Other local ventilation devices. Ventilated storage cabinets, canopy hoods, snorkels, etc. should be provided as needed (199). Each canopy hood and snorkel should have a separate exhaust duct (207).

(d) Special ventilation areas. Exhaust air from glove boxes and isolation rooms should be passed through scrubbers or other treatment before release into the regular exhaust system (208). Cold rooms and warm rooms should have provisions for rapid escape and for escape in the event of electrical failure (209).

(e) Modifications. Any alteration of the ventilation system should be made only if thorough testing indicates that worker protection from airborne toxic substances will continue to be adequate (12, 193, 204).

(f) Performance. Rate: 4-12 room air changes/hour is normally adequate general ventilation if local exhaust systems such as hoods are used as the primary method of control (194).

(g) Quality. General air flow should not be turbulent and should be relatively uniform throughout the laboratory, with no high velocity or static areas (194, 195); airflow into and within the hood should not be excessively turbulent (200); hood face velocity should be adequate (typically 60-100 lfm) (200, 204).

(h) Evaluation. Quality and quantity of ventilation should be evaluated on installation (202), regularly monitored (at least every 3 months) (6, 12, 14, 195), and reevaluated whenever a change in local ventilation devices is made (12, 195, 207). See pp 195-198 for methods of evaluation and for calculation of estimated airborne contaminant concentrations.

D. Components of the Chemical Hygiene Plan
1. Basic Rules and Procedures (Recommendations for these are given in section E, below)
2. Chemical Procurement, Distribution, and Storage

(a) Procurement. Before a substance is received, information on proper handling, storage, and disposal should be known to those who will be involved (215, 216). No container should be accepted without an adequate identifying label (216). Preferably, all substances should be received in a central location (216).

(b) Stockrooms/storerooms. Toxic substances should be segregated in a well-identified area with local exhaust ventilation (221). Chemicals which are highly toxic (227) or other chemicals whose containers have been opened should be in unbreakable secondary containers (219). Stored chemicals should be examined periodically (at least annually) for replacement, deterioration, and container integrity (218-19).

Stockrooms/storerooms should not be used as preparation or repackaging areas, should be open during normal working hours, and should be controlled by one person (219).

(c) Distribution. When chemicals are hand carried, the container should be placed in an outside container or bucket. Freight-only elevators should be used if possible (223).

(d) Laboratory storage. Amounts permitted should be as small as practical. Storage on bench tops and in hoods is inadvisable. Exposure to heat or direct sunlight should be avoided. Periodic inventories should be conducted, with unneeded items being discarded or returned to the storeroom/stockroom (225-6, 229).

3. Environmental Monitoring

Regular instrumental monitoring of airborne concentrations is not usually justified or practical in laboratories but may be appropriate when testing or redesigning hoods or other ventilation devices (12) or when a highly toxic substance is stored or used regularly (e.g., 3 times/week) (13).

4. Housekeeping, Maintenance, and Inspections

(a) Cleaning. Floors should be cleaned regularly (24).

(b) Inspections. Formal housekeeping and chemical hygiene inspections should be held at least quarterly (6, 21) for units which have frequent personnel changes and semiannually for others; informal inspections should be continual (21).

(c) Maintenance. Eye wash fountains should be inspected at intervals of not less than 3 months (6). Respirators for routine use should be inspected periodically by the laboratory supervisor (169). Other safety equipment should be inspected regularly. (e.g., every 3-6 months) (6, 24, 171). Procedures to prevent restarting of out-of-service equipment should be established (25).

(d) Passageways. Stairways and hallways should not be used as storage areas (24). Access to exits, emergency equipment, and utility controls should never be blocked (24).

5. Medical Program

(a) Compliance with regulations. Regular medical surveillance should be established to the extent required by regulations (12).

(b) Routine surveillance. Anyone whose work involves regular and frequent handling of toxicologically significant quantities of a chemical should consult a qualified physician to determine on an individual basis whether a regular schedule of medical surveillance is desirable (11, 50).

(c) First aid. Personnel trained in first aid should be available during working hours and an emergency room with medical personnel should be nearby (173). See pp. 176-178 for description of some emergency first aid procedures.

6. Protective Apparel and Equipment

These should include for each laboratory:

(a) Protective apparel compatible with the required degree of protection for substances being handled (158-161);

(b) An easily accessible drench-type safety shower (162, 169);

(c) An eyewash fountain (162)

(d) A fire extinguisher (162-164);

(e) Respiratory protection (164-9), fire alarm and telephone for emergency use (162) should be available nearby; and

(f) Other items designated by the laboratory supervisor (156, 160).

7. Records

(a) Accident records should be written and retained (174).

(b) Chemical Hygiene Plan records should document that the facilities and precautions were compatible with current knowledge and regulations (7).
(c) Inventory and usage records for high-risk substances should be kept as specified in sections E3e below.

(d) Medical records should be retained by the institution in accordance with the requirements of state and federal regulations (12).

8. Signs and Labels

Prominent signs and labels of the following types should be posted:

(a) Emergency telephone numbers of emergency personnel/facilities, supervisors, and laboratory workers (28);

(b) Identity labels, showing contents of containers (including waste receptacles) and associated hazards (27, 48);

(c) Location signs for safety showers, eyewash stations, other safety and first aid equipment, exits (27) and areas where food and beverage consumption and storage are permitted (24); and

(d) Warnings at areas or equipment where special or unusual hazards exist (27).

9. Spills and Accidents

(a) A written emergency plan should be established and communicated to all personnel; it should include procedures for ventilation failure (200), evacuation, medical care, reporting, and drills (172).

(b) There should be an alarm system to alert people in all parts of the facility including isolation areas such as cold rooms (172).

(c) A spill control policy should be developed and should include consideration of prevention, containment, cleanup, and reporting (175).

(d) All accidents or near accidents should be carefully analyzed with the results distributed to all who might benefit (8, 28).

10. Information and Training Program

(a) Aim: To assure that all individuals at risk are adequately informed about the work in the laboratory, its risks, and what to do if an accident occurs (5, 15).

(b) Emergency and Personal Protection Training: Every laboratory worker should know the location and proper use of available protective apparel and equipment (154, 169).

Some of the full-time personnel of the laboratory should be trained in the proper use of emergency equipment and procedures (6).

Such training as well as first aid instruction should be available to (154) and encouraged for (176) everyone who might need it.

(c) Receiving and stockroom/storeroom personnel should know about hazards, handling equipment, protective apparel, and relevant regulations (217).

(d) Frequency of Training: The training and education program should be a regular, continuing activity - not simply an annual presentation (15).

(e) Literature/Consultation: Literature and consulting advice concerning chemical hygiene should be readily available to laboratory personnel, who should be encouraged to use these information resources (14).

11. Waste Disposal Program.

(a) Aim: To assure that minimal harm to people, other organisms, and the environment will result from the disposal of waste laboratory chemicals (5).

(b) Content (14, 232, 233, 240): The waste disposal program should specify how waste is to be collected, segregated, stored, and transported and include consideration of what materials can be incinerated. Transport from the institution must be in accordance with DOT regulations (244).

(c) Discarding Chemical Stocks: Unlabeled containers of chemicals and solutions should undergo prompt disposal; if partially used, they should not be opened (24, 27).

Before a worker's employment in the laboratory ends, chemicals for which that person was responsible should be discarded or returned to storage (226).

(d) Frequency of Disposal: Waste should be removed from laboratories to a central waste storage area at least once per week and from the central waste storage area at regular intervals (14).

(e) Method of Disposal: Incineration in an environmentally acceptable manner is the most practical disposal method for combustible laboratory waste (14, 238, 241).

Indiscriminate disposal by pouring waste chemicals down the drain (14, 231, 242) or adding them to mixed refuse for landfill burial is unacceptable (14).

Hoods should not be used as a means of disposal for volatile chemicals (40, 200).

Disposal by recycling (233, 243) or chemical decontamination (40, 230) should be used when possible.

E. Basic Rules and Procedures for Working with Chemicals

The Chemical Hygiene Plan should require that laboratory workers know and follow its rules and procedures. In addition to the procedures of the sub programs mentioned above, these should include the rules listed below.

1. General Rules

The following should be used for essentially all laboratory work with chemicals:

(a) Accidents and spills - Eye Contact: Promptly flush eyes with water for a prolonged period (15 minutes) and seek medical attention (33, 172).

Ingestion: Encourage the victim to drink large amounts of water (178).

Skin Contact: Promptly flush the affected area with water (33, 172, 178) and remove any contaminated clothing (172, 178). If symptoms persist after washing, seek medical attention (33).

Clean-up. Promptly clean up spills, using appropriate protective apparel and equipment and proper disposal (24, 33). See pp. 233-237 for specific clean-up recommendations.

(b) Avoidance of "routine" exposure: Develop and encourage safe habits (23); avoid unnecessary exposure to chemicals by any route (23);

Do not smell or taste chemicals (32). Vent apparatus which may discharge toxic chemicals (vacuum pumps, distillation columns, etc.) into local exhaust devices (199).

Inspect gloves (157) and test glove boxes (208) before use.

Do not allow release of toxic substances in cold rooms and warm rooms, since these have contained recirculated atmospheres (209).

(c) Choice of chemicals: Use only those chemicals for which the quality of the available ventilation system is appropriate (13).

(d) Eating, smoking, etc.: Avoid eating, drinking, smoking, gum chewing, or application of cosmetics in areas where laboratory chemicals are present (22, 24, 32, 40); wash hands before conducting these activities (23, 24).

Avoid storage, handling, or consumption of food or beverages in storage areas, refrigerators, glassware or utensils which are also used for laboratory operations (23, 24, 226).

(e) Equipment and glassware: Handle and store laboratory glassware with care to avoid damage; do not use damaged glassware (25). Use extra care with Dewar flasks and other evacuated glass apparatus; shield or wrap them to contain chemicals and fragments should implosion occur (25). Use equipment only for its designed purpose (23, 26).

(f) Exiting: Wash areas of exposed skin well before leaving the laboratory (23).

(g) Horseplay: Avoid practical jokes or other behavior which might confuse, startle or distract another worker (23).

(h) Mouth suction: Do not use mouth suction for pipeting or starting a siphon (23, 32).

(i) Personal apparel: Confine long hair and loose clothing (23, 158). Wear shoes at all times in the laboratory but do not wear sandals, perforated shoes, or sneakers (158).

(j) Personal housekeeping: Keep the work area clean and uncluttered, with chemicals and equipment being properly labeled and stored; clean up the work area on completion of an operation or at the end of each day (24).

(k) Personal protection: Assure that appropriate eye protection (154-156) is worn by all persons, including visitors, where chemicals are stored or handled (22, 23, 33, 154).

Wear appropriate gloves when the potential for contact with toxic materials exists (157); inspect the gloves before each use, wash them before removal, and replace them periodically (157). (A table of resistance to chemicals of common glove materials is given p. 159).

Use appropriate (164-168) respiratory equipment when air contaminant concentrations are not sufficiently restricted by engineering controls (164-5), inspecting the respirator before use (169).

Use any other protective and emergency apparel and equipment as appropriate (22, 157-162).

Avoid use of contact lenses in the laboratory unless necessary; if they are used, inform supervisor so special precautions can be taken (155).

Remove laboratory coats immediately on significant contamination (161).

(l) Planning: Seek information and advice about hazards (7), plan appropriate protective procedures, and plan positioning of equipment before beginning any new operation (22, 23).

(m) Unattended operations: Leave lights on, place an appropriate sign on the door, and provide for containment of toxic substances in the event of failure of a utility service (such as cooling water) to an unattended operation (27, 128).

(n) Use of hood: Use the hood for operations which might result in release of toxic chemical vapors or dust (198-9).

As a rule of thumb, use a hood or other local ventilation device when working with any appreciably volatile substance with a TLV of less than 50 ppm (13).

Confirm adequate hood performance before use; keep hood closed at all times except when adjustments within the hood are being made (200); keep materials stored in hoods to a minimum and do not allow them to block vents or air flow (200).

Leave the hood "on" when it is not in active use if toxic substances are stored in it or if it is uncertain whether adequate general laboratory ventilation will be maintained when it is "off" (200).

(o) Vigilance: Be alert to unsafe conditions and see that they are corrected when detected (22).

(p) Waste disposal: Assure that the plan for each laboratory operation includes plans and training for waste disposal (230).

Deposit chemical waste in appropriately labeled receptacles and follow all other waste disposal procedures of the Chemical Hygiene Plan (22, 24).

Do not discharge to the sewer concentrated acids or bases (231); highly toxic, malodorous, or lachrymatory substances (231); or any substances which might interfere with the biological activity of waste water treatment plants, create fire or explosion hazards, cause structural damage or obstruct flow (242).

(q) Working alone: Avoid working alone in a building; do not work alone in a laboratory if the procedures being conducted are hazardous (28).

2. Working with Allergens and Embryotoxins

(a) Allergens (examples: diazomethane, isocyanates, bichromates): Wear suitable gloves to prevent hand contact with allergens or substances of unknown allergenic activity (35).

(b) Embryotoxins (34-5) (examples: organomercurials, lead compounds, formamide): If you are a woman of childbearing age, handle these substances only in a hood whose satisfactory performance has been confirmed, using appropriate protective apparel (especially gloves) to prevent skin contact.

Review each use of these materials with the research supervisor and review continuing uses annually or whenever a procedural change is made.

Store these substances, properly labeled, in an adequately ventilated area in an unbreakable secondary container.

Notify supervisors of all incidents of exposure or spills; consult a qualified physician when appropriate.

3. Work with Chemicals of Moderate Chronic or High Acute Toxicity

Examples: diisopropylfluorophosphate (41), hydrofluoric acid (43), hydrogen cyanide (45).

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Supplemental rules to be followed in addition to those mentioned above (Procedure B of "Prudent Practices", pp. 39-41):

(a) Aim: To minimize exposure to these toxic substances by any route using all reasonable precautions (39).

(b) Applicability: These precautions are appropriate for substances with moderate chronic or high acute toxicity used in significant quantities (39).

(c) Location: Use and store these substances only in areas of restricted access with special warning signs (40, 229).

Always use a hood (previously evaluated to confirm adequate performance with a face velocity of at least 60 linear feet per minute) (40) or other containment device for procedures which may result in the generation of aerosols or vapors containing the substance (39); trap released vapors to revent their discharge with the hood exhaust (40).

(d) Personal protection: Always avoid skin contact by use of gloves and long sleeves (and other protective apparel as appropriate) (39). Always wash hands and arms immediately after working with these materials (40).

(e) Records: Maintain records of the amounts of these materials on hand, amounts used, and the names of the workers involved (40, 229).

(f) Prevention of spills and accidents: Be prepared for accidents and spills (41).

Assure that at least 2 people are present at all times if a compound in use is highly toxic or of unknown toxicity (39).

Store breakable containers of these substances in chemically resistant trays; also work and mount apparatus above such trays or cover work and storage surfaces with removable, absorbent, plastic backed paper (40).

If a major spill occurs outside the hood, evacuate the area; assure that cleanup personnel wear suitable protective apparel and equipment (41).

(g) Waste: Thoroughly decontaminate or incinerate contaminated clothing or shoes (41). If possible, chemically decontaminate by chemical conversion (40).

Store contaminated waste in closed, suitably labeled, impervious containers (for liquids, in glass or plastic bottles half-filled with vermiculite) (40).

4. Work with Chemicals of High Chronic Toxicity

(Examples: dimethylmercury and nickel carbonyl (48), benzo-a-pyrene (51), N-nitrosodiethylamine (54), other human carcinogens or substances with high carcinogenic potency in animals (38).)

Further supplemental rules to be followed, in addition to all these mentioned above, for work with substances of known high chronic toxicity (in quantities above a few milligrams to a few grams, depending on the substance) (47). (Procedure A of "Prudent Practices" pp. 47-50).

(a) Access: Conduct all transfers and work with these substances in a "controlled area": a restricted access hood, glove box, or portion of a lab, designated for use of highly toxic substances, for which all people with access are aware of the substances being used and necessary precautions (48).

(b) Approvals: Prepare a plan for use and disposal of these materials and obtain the approval of the laboratory supervisor (48).

(c) Non-contamination/Decontamination: Protect vacuum pumps against contamination by scrubbers or HEPA filters and vent them into the hood (49). Decontaminate vacuum pumps or other contaminated equipment, including glassware, in the hood before removing them from the controlled area (49, 50).

Decontaminate the controlled area before normal work is resumed there (50).

(d) Exiting: On leaving a controlled area, remove any protective apparel (placing it in an appropriate, labeled container) and thoroughly wash hands, forearms, face, and neck (49).

(e) Housekeeping: Use a wet mop or a vacuum cleaner equipped with a HEPA filter instead of dry sweeping if the toxic substance was a dry powder (50).

(f) Medical surveillance: If using toxicologically significant quantities of such a substance on a regular basis (e.g., 3 times per week), consult a qualified physician concerning desirability of regular medical surveillance (50).

(g) Records: Keep accurate records of the amounts of these substances stored (229) and used, the dates of use, and names of users (48).

(h) Signs and labels: Assure that the controlled area is conspicuously marked with warning and restricted access signs (49) and that all containers of these substances are appropriately labeled with identity and warning labels (48).

(i) Spills: Assure that contingency plans, equipment, and materials to minimize exposures of people and property in case of accident are available (233-4).

(j) Storage: Store containers of these chemicals only in a ventilated, limited access (48, 227, 229) area in appropriately labeled, unbreakable, chemically resistant, secondary containers (48, 229).

(k) Glove boxes: For a negative pressure glove box, ventilation rate must be at least 2 volume changes/hour and pressure at least 0.5 inches of water (48). For a positive pressure glove box, thoroughly check for leaks before each use (49). In either case, trap the exit gases or filter them through a HEPA filter and then release them into the hood (49).

(l) Waste: Use chemical decontamination whenever possible; ensure that containers of contaminated waste (including washings from contaminated flasks) are transferred from the controlled area in a secondary container under the supervision of authorized personnel (49, 50, 233).

5. Animal Work with Chemicals of High Chronic Toxicity
(a) Access: For large scale studies, special facilities with restricted access are preferable (56).

(b) Administration of the toxic substance: When possible, administer the substance by injection or gavage instead of in the diet. If administration is in the diet, use a caging system under negative pressure or under laminar air flow directed toward HEPA filters (56).

(c) Aerosol suppression: Devise procedures which minimize formation and dispersal of contaminated aerosols, including those from food, urine, and feces (e.g., use HEPA filtered vacuum equipment for cleaning, moisten contaminated bedding before removal from the cage, mix diets in closed containers in a hood) (55, 56).

(d) Personal protection: When working in the animal room, wear plastic or rubber gloves, fully buttoned laboratory coat or jumpsuit and, if needed because of incomplete suppression of aerosols, other apparel and equipment (shoe and head coverings, respirator) (56).

(e) Waste disposal: Dispose of contaminated animal tissues and excreta by incineration if the available incinerator can convert the contaminant to non-toxic products (238); otherwise, package the waste appropriately for burial in an EPA-approved site (239).

F. Safety Recommendations

The above recommendations from "Prudent Practices" do not include those which are directed primarily toward prevention of physical injury rather than toxic exposure. However, failure of precautions against injury will often have the secondary effect of causing toxic exposures. Therefore, we list below page references for recommendations concerning some of the major categories of safety hazards which also have implications for chemical hygiene:

1. Corrosive agents: (35-6)
2. Electrically powered laboratory apparatus: (179-92)
3. Fires, explosions: (26, 57-74, 162-64, 174-5, 219-20, 226-7)
4. Low temperature procedures: (26, 88)
5. Pressurized and vacuum operations (including use of compressed gas cylinders): (27, 75-101)

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G. Material Safety Data Sheets

Material safety data sheets are presented in "Prudent Practices" for the chemicals listed below. (Asterisks denote that comprehensive material safety data sheets are provided).

o Acetyl peroxide (105)	Diisopropyl fluorophosphate (41)	o Peracetic acid (141)
o Acrolein (106)	o Dimethylformamide (123)	o Phenol (142)
o Acrylonitrile	o Dimethyl sulfate (125)	o Phosgene (143)
Ammonia (anhydrous)(91)	o Dioxane (126)	o Pyridine (144)
o Aniline (109)	o Ethylene dibromide (128)	o Sodium azide (145)
o Benzene (110)	o Fluorine (95)	o Sodium cyanide (147)
o Benzo[a]pyrene (112)	o Formaldehyde (130)	Sulfur dioxide (101)
o Bis(chloromethyl) ether (113)	o Hydrazine and salts (132)	o Trichloroethylene (149)
Boron trichloride (91)	Hydrofluoric acid (43)	o Vinyl chloride (150)
Boron trifluoride (92)	Hydrogen bromide (98)	N-nitrosodiethylamine (54)
Bromine (114)	Hydrogen chloride (98)	o Peracetic acid (141)
o Tert-butyl hydroperoxide (148)	o Hydrogen cyanide (133)	o Phenol (142)
o Carbon disulfide (116)	o Hydrogen sulfide (135)	o Phosgene (143)
Carbon monoxide (92)	Mercury and compounds (52)	o Pyridine (144)
o Carbon tetrachloride (118)	o Methanol (137)	o Sodium azide (145)
*Chlorine (119)	o Morpholine (138)	o Sodium cyanide (147)
Chlorine trifluoride (94)	Nickel carbonyl (99)	Sulfur dioxide (101)
o Chloroform (121)	o Nitrobenzene (139)	
Chloromethane (93)	Nitrogen dioxide (100)	
o Diethyl ether (122)	N-nitrosodiethylamine (54)	

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Appendix B

Occupational Exposure

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Appendix B

Occupational exposure to hazardous chemicals in laboratories. - 1910.1450

OSHA Regulations (Standards - 29 CFR) - Table of Contents

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* Standard Number: 1910.1450
* Standard Title: Occupational exposure to hazardous chemicals in laboratories.
* SubPart Number: Z
* SubPart Title: Toxic and Hazardous Substances

Interpretation(s)

(a)
Scope and application.

(a)(1)
This section shall apply to all employers engaged in the laboratory use of hazardous chemicals as defined below.

(a)(2)
Where this section applies, it shall supersede, for laboratories, the requirements of all other OSHA health standards in 29 CFR part 1910, subpart Z, except as follows:
(a)(2)(i)

For any OSHA health standard, only the requirement to limit employee exposure to the specific permissible exposure limit shall apply for laboratories, unless that particular standard states otherwise or unless the conditions of paragraph (a)(2)(iii) of this section apply.

(a)(2)(ii)
Prohibition of eye and skin contact where specified by any OSHA health standard shall be observed.

(a)(2)(iii)
Where the action level (or in the absence of an action level, the permissible exposure limit) is routinely exceeded for an OSHA regulated substance with exposure monitoring and medical surveillance requirements paragraphs (d) and (g)(1)(ii) of this section shall apply.

(a)(3) This section shall not apply to:
..1910.1450(a)(3)(i)
(a)(3)(i)
Uses of hazardous chemicals which do not meet the definition of laboratory use, and in such cases, the employer shall comply with the relevant standard in 29 CFR part 1910, subpart 2, even if such use occurs in a laboratory.

(a)(3)(ii)
Laboratory uses of hazardous chemicals which provide no potential for employee exposure. Examples of such conditions might include:

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(a)(3)(ii)(A)
Procedures using chemically-impregnated test media such as Dip-and-Read tests where a reagent strip is dipped into the specimen to be tested and the results are interpreted by comparing the color reaction to a color chart supplied by the manufacturer of the test strip; and

(a)(3)(ii)(B)
Commercially prepared kits such as those used in performing pregnancy tests in which all of the reagents needed to conduct the test are contained in the kit.

(b)
Definitions -
"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.

"Assistant Secretary" means the Assistant Secretary of Labor for Occupational Safety and Health, U.S. Department of Labor, or designee.

"Carcinogen" (see "select carcinogen").

"Chemical Hygiene Officer" means an employee who is designated by the employer, 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 which sets forth procedures, equipment, personal protective equipment and work practices that (i) are capable of protecting employees from the health hazards presented by hazardous chemicals used in that particular workplace and (ii) meets the requirements of paragraph (e) of this section.

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

"Compressed gas" means:
(i) A gas or mixture of gases having, in a container, an absolute pressure exceeding 40 psi at 70 deg. F (21.1 deg. C); or

(ii) A gas or mixture of gases having, in a container, an absolute pressure exceeding 104 psi at 130 deg. F (54.4 deg C) regardless of the pressure at 70 deg. F (21.1 deg. C); or

(iii) A liquid having a vapor pressure exceeding 40 psi at 100 deg. F (37.8 C) as determined by ASTM D-323-72.

"Designated area" means an area which may be used for work with "select carcinogens," reproductive toxins or substances which 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 which 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:

(i) "Aerosol, flammable" means an aerosol that, when tested by the method described in 16 CFR 1500.45, yields a flame protection exceeding 18 inches at full valve opening, or a flashback (a flame extending back to the valve) at any degree of valve opening;

(ii) "Gas, flammable" means:

(A) 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

(B) 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.

(iii) "Liquid, flammable" means any liquid having a flashpoint below 100 deg F (37.8 deg. C), except any mixture having components with flashpoints of 100 deg. C) or higher, the total of which make up 99 percent or more of the total volume of the mixture.

(iv) "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 which 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 when tested as follows:

(i) Tagliabue Closed Tester (See American National Standard Method of Test for Flash Point by Tag Closed Tester, Z11.24 - 1979 (ASTM D 56-79)) - for liquids with a viscosity of less than 45 Saybolt Universal Seconds (SUS) at 100 deg. F (37.8 deg. C), that do not contain suspended solids and do not have a tendency to form a surface film under test; or

(ii) Pensky-Martens Closed Tester (See American National Standard Method of Test for Flashpoint by Pensky-Martens Closed Tester, Z11.7 - 1979 (ASTM D 93-79)) - for liquids with a viscosity equal to or

greater than 45 SUS at 100 deg. F (37.8 deg. C), or that contain suspended solids, or that have a tendency to form a surface film under test; or

(iii) Setaflash Closed Tester (see American National Standard Method of test for Flash Point by Setaflash Closed Tester (ASTM D 3278-78)).

Organic peroxides, which undergo autoaccelerating thermal decomposition, are excluded from any of the flashpoint determination methods specified above.

"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 which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic systems, and agents which damage the lungs, skin, eyes, or mucous membranes.

Appendices 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 or not 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 non-production 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 safety 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 provided that 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 of the following conditions are met:

(i) Chemical manipulations are carried out on a "laboratory scale;"
(ii) Multiple chemical procedures or chemicals are used;

(iii) The procedures involved are not part of a production process, nor in any way simulate a production process; and

(iv) "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 which 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 which 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 tat 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 which affect the reproductive chemicals which affect the reproductive capabilities including chromosomal damage (mutations) and effects on fetuses (teratogenesis).

"Select carcinogen" means any substance which meets one of the following criteria:

(i) It is regulated by OSHA as a carcinogen; or

(ii) It is listed under the category, "known to be carcinogens," in the Annual Report on Carcinogens published by the National Toxicology Program (NTP)(latest edition); or

(iii) It is listed under Group 1 ("carcinogenic to humans") by the International Agency for research on Cancer Monographs (IARC)(latest editions); or

(iv) It is listed in either Group 2A or 2B by IARC or under the category, "reasonably anticipated to be carcinogens" by NTP, and causes statistically significant tumor incidence in experimental animals in accordance with any of the following criteria:

(A) After inhalation exposure of 6-7 hours per day, 5 days per week, for a significant portion of a lifetime to dosages of less than 10 mg/m(3);

(B) After repeated skin application of less than 300 (mg/kg of body weight) per week; or

(C) After oral dosages of less than 50 mg/kg of body weight per day.

"Unstable (reactive)" means a chemical which 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.

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

(c) Permissible exposure limits. For laboratory uses of OSHA regulated substances, the employer shall assure that laboratory employees' exposures to such substances do not exceed the permissible exposure limits specified in 29 CFR part 1910, subpart Z.

1910.1450(d) Employee exposure determination
(d)(1)
Initial monitoring. The employer shall measure the employee's exposure to any substance regulated by a standard which requires monitoring if there is reason to believe that exposure levels for that substance routinely exceed the action level (or in the absence of an action level, the PEL).

(d)(2)
Periodic monitoring. If the initial monitoring prescribed by paragraph (d)(1) of this section discloses employee exposure over the action level (or in the absence of an action level, the PEL), the employer shall immediately comply with the exposure monitoring provisions of the relevant standard.

(d)(3)
Termination of monitoring. Monitoring may be terminated in accordance with the relevant standard.

(d)(4)
Employee notification of monitoring results. The employer shall, within 15 working days after the receipt of any monitoring results, notify the employee of these results in writing either individually or by posting results in an appropriate location that is accessible to employees.

(e)
Chemical hygiene plan - General. (Appendix A of this section is non-mandatory but provides guidance to assist employers in the development of the Chemical Hygiene Plan).

(e)(1)
Where hazardous chemicals as defined by this standard are used in the workplace, the employer shall develop and carry out the provisions of a written Chemical Hygiene Plan which is:

(e)(1)(i)
Capable of protecting employees from health hazards associated with hazardous chemicals in that laboratory and

1910.1450(e)(1)(ii)
(e)(1)(ii)
Capable of keeping exposures below the limits specified in paragraph (c) of this section.

(e)(2)
The Chemical Hygiene Plan shall be readily available to employees, employee representatives and, upon request, to the Assistant Secretary.

(e)(3)
The Chemical Hygiene Plan shall include each of the following elements and shall indicate specific measures that the employer will take to ensure laboratory employee protection;

(e)(3)(i)
Standard operating procedures relevant to safety and health considerations to be followed when laboratory work involves the use of hazardous chemicals;

(e)(3)(ii)
Criteria that the employer will use to determine and implement control measures to reduce employee exposure to hazardous chemicals including engineering controls, the use of personal protective equipment and hygiene practices; particular attention shall be given to the selection of control measures for chemicals that are known to be extremely hazardous;

(e)(3)(iii)
A requirement that fume hoods and other protective equipment are functioning properly and specific measures that shall be taken to ensure proper and adequate performance of such equipment;

1910.1450(e)(3)(iv)
(e)(3)(iv)
Provisions for employee information and training as prescribed in paragraph (f) of this section;

(e)(3)(v)
The circumstances under which a particular laboratory operation, procedure or activity shall require prior approval from the employer or the employer's designee before implementation;

(e)(3)(vi)
Provisions for medical consultation and medical examinations in accordance with paragraph (g) of this section;

(e)(3)(vii)
Designation of personnel responsible for implementation of the Chemical Hygiene Plan including the assignment of a Chemical Hygiene Officer, and, if appropriate, establishment of a Chemical Hygiene Committee; and

(e)(3)(viii)
Provisions for additional employee protection for work with particularly hazardous substances. These include "select carcinogens," reproductive toxins and substances which have a high degree of acute toxicity. Specific consideration shall be given to the following provisions which shall be included where appropriate:

(e)(3)(viii)(A)
Establishment of a designated area;

(e)(3)(viii)(B)
Use of containment devices such as fume hoods or glove boxes;

(e)(3)(viii)(C)
Procedures for safe removal of contaminated waste; and

1910.1450(e)(3)(viii)(D)
(e)(3)(viii)(D)
Decontamination procedures.
(e)(4)
The employer shall review and evaluate the effectiveness of the Chemical Hygiene Plan at least annually and update it as necessary.

(f)
Employee information and training.

(f)(1)
The employer shall provide employees with information and training to ensure that they are apprised of the hazards of chemicals present in their work area.

(f)(2)
Such information shall be provided at the time of an employee's initial assignment to a work area where hazardous chemicals are present and prior to assignments involving new exposure situations. The frequency of refresher information and training shall be determined by the employer.

(f)(3)
Information. Employees shall be informed of:

(f)(3)(i)
The contents of this standard and its appendices which shall be made available to employees;
(f)(3)(ii)

the location and availability of the employer's Chemical Hygiene Plan;
..1910.1450(f)(3)(iii)
(f)(3)(iii)
The permissible exposure limits for OSHA regulated substances or recommended exposure limits for other hazardous chemicals where there is no applicable OSHA standard;

(f)(3)(iv)
Signs and symptoms associated with exposures to hazardous chemicals used in the laboratory; and

(f)(3)(v)
The location and availability of known reference material on the hazards, safe handling, storage and disposal of hazardous chemicals found in the laboratory including, but not limited to, Material Safety Data Sheets received from the chemical supplier.

(f)(4)
Training.
(f)(4)(i)
Employee training shall include:
(f)(4)(i)(A)
Methods and observations that may be used to detect the presence or release of a hazardous chemical (such as monitoring conducted by the employer, continuous monitoring devices, visual appearance or odor of hazardous chemicals when being released, etc.);

(f)(4)(i)(B)
The physical and health hazards of chemicals in the work area; and

(f)(4)(i)(C)
The measures employees can take to protect themselves from these hazards, including specific procedures the employer has implemented to protect employees from exposure to hazardous chemicals, such as appropriate work practices, emergency procedures, and personal protective equipment to be used.

..1910.1450(f)(4)(ii)
(f)(4)(ii)
The employee shall be trained on the applicable details of the employer's written Chemical Hygiene Plan.

(g)
Medical consultation and medical examinations.

(g)(1)
The employer shall provide all employees who work with hazardous chemicals an opportunity to receive medical attention, including any follow-up examinations which the examining physician determines to be necessary, under the following circumstances:

(g)(1)(i)
Whenever an employee develops signs or symptoms associated with a hazardous chemical to which the employee may have been exposed in the laboratory, the employee shall be provided an opportunity to receive an appropriate medical examination.

(g)(1)(ii)
Where exposure monitoring reveals an exposure level routinely above the action level (or in the absence of an action level, the PEL) for an OSHA regulated substance for which there are exposure monitoring and medical surveillance requirements, medical surveillance shall be established for the affected employee as prescribed by the particular standard.

(g)(1)(iii)
Whenever an event takes place in the work area such as a spill, leak, explosion or other occurrence resulting in the likelihood of a hazardous exposure, the affected employee shall be provided an opportunity for a medical consultation. Such consultation shall be for the purpose of determining the need for a medical examination.

..1910.1450(g)(2)
(g)(2)
All medical examinations and consultations shall be performed by or under the direct supervision of a licensed physician and shall be provided without cost to the employee, without loss of pay and at a reasonable time and place.

(g)(3)
Information provided to the physician. The employer shall provide the following information to the physician:

(g)(3)(i)
The identity of the hazardous chemical(s) to which the employee may have been exposed;

(g)(3)(ii)
A description of the conditions under which the exposure occurred including quantitative exposure data, if available; and

(g)(3)(iii)
A description of the signs and symptoms of exposure that the employee is experiencing, if any.

(g)(4)
Physician's written opinion.

(g)(4)(i)
For examination or consultation required under this standard, the employer shall obtain a written opinion from the examining physician which shall include the following:

(g)(4)(i)(A)
Any recommendation for further medical follow-up;

(g)(4)(i)(B)
The results of the medical examination and any associated tests;

..1910.1450(g)(4)(i)(C)
(g)(4)(i)(C)
Any medical condition which may be revealed in the course of the examination which may place the employee at increased risk as a result of exposure to a hazardous workplace; and

(g)(4)(i)(D)
A statement that the employee has been informed by the physician of the results of the consultation or medical examination and any medical condition that may require further examination or treatment.

(g)(4)(ii)
The written opinion shall not reveal specific findings of diagnoses unrelated to occupational exposure.

(h)
Hazard identification.

(h)(1)
With respect to labels and material safety data sheets:

(h)(1)(i)
Employers shall ensure that labels on incoming containers of hazardous chemicals are not removed or defaced.

(h)(1)(ii)
Employers shall maintain any material safety data sheets that are received with incoming shipments of hazardous chemicals, and ensure that they are readily accessible to laboratory employees.

(h)(2)
The following provisions shall apply to chemical substances developed in the laboratory:

910.1450(h)(2)(i)
(h)(2)(i)
If the composition of the chemical substance which is produced exclusively for the laboratory's use is known, the employer shall determine if it is a hazardous chemical as defined in paragraph (b) of this section. If the chemical is determined to be hazardous, the employer shall provide appropriate training as required under paragraph (f) of this section.

(h)(2)(ii)
If the chemical produced is a byproduct whose composition is not known, the employer shall assume that the substance is hazardous and shall implement paragraph (e) of this section.

(h)(2)(iii)
If the chemical substance is produced for another user outside of the laboratory, the employer shall comply with the Hazard Communication Standard (29 CFR 1910.1200) including the requirements for preparation of material safety data sheets and labeling.

(i)
Use of respirators. Where the use of respirators is necessary to maintain exposure below permissible exposure limits, the employer shall provide, at no cost to the employee, the proper respiratory equipment. Respirators shall be selected and used in accordance with the requirements of 29 CFR 1910.134.

(j)
Recordkeeping.

(j)(1)
The employer shall establish and maintain for each employee an accurate record of any measurements taken to monitor employee exposures and any medical consultation and examinations including tests or written opinions required by this standard.

..1910.1450(j)(2)

(j)(2)
The employer shall assure that such records are kept, transferred, and made available in accordance with 29 CFR 1910.1020.

(k)
Dates -
(k)(1)
Effective date. This section shall become effective May 1, 1990.

(k)(2)
Start-up dates.

(k)(2)(i)
Employers shall have developed and implemented a written Chemical Hygiene Plan no later than January 31, 1991.

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(k)(2)(ii)
Paragraph (a)(2) of this section shall not take effect until the employer has developed and implemented a written Chemical Hygiene Plan.

(l)
Appendices. The information contained in the appendices is not intended, by itself, to create any additional obligations not otherwise imposed or to detract from any existing obligation.
[61 FR 5507, Feb. 13, 1996]

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Appendix C

Contracts and Forms

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Laboratory Inspection Checklist

Conducted By: _____ Date of Inspection: _____

Location (room # & building): _____

Principal Investigator/Supervisor: _____

I. Laboratory Work Practices

	Yes/No	Comments
✓ No smoking, food & beverages rules are observed. ✓ Food and beverages are not stored in the laboratory areas, refrigerators or in glassware that is also used for laboratory operations.	Yes/No	
✓ Pipeting is performed by mechanical means.	Yes/No	
✓ Laboratory surfaces are cleaned; disinfected or decontaminated after work is performed.	Yes/No	
✓ Required PPE is being worn.	Yes/No	
✓ Used needles are stored in appropriate sharps containers		
✓ Syringes are needle locking..	Yes/No	
✓ No recapping of needles is performed.	Yes/No	
✓ Hoods are not being used for storage.	Yes/No	

II. Housekeeping

	Yes/No	**Comments**
✓ Laboratory and storage areas uncluttered and orderly (including benchtop).	Yes/No	
✓ Aisles & exits are free from obstruction.	Yes/No	
✓ Work surfaces are protected from contamination.	Yes/No	
✓ Electrical cords are in good condition and are UL listed.	Yes/No	
✓ Tools and equipment are in good repair and electrically grounded.	Yes/No	
✓ Tops of cabinets and shelves are free from stored items.	Yes/No	
✓ Heavy objects are confined to lower shelves.	Yes/No	
✓ Glassware is free from cracks, chips, sharp edges and other defects.	Yes/No	
✓ Broken glass containers are available and in use.	Yes/No	

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III. Personal Protective Equipment

		Yes/No	Comments
✓	Protective gloves are available and matched to hazards involved.	Yes/No	
✓	Eye protection is available and in use in all laboratories.	Yes/No	
✓	Lab coats, tyvek garments etc. are available and in use.	Yes/No	
✓	Lab coats are only worn in the laboratory and are removed before entering offices, lunchrooms, rest rooms, conference rooms and other non-laboratory general use areas. (This includes disposable protective clothing).	Yes/No	
✓	Dirty lab coats/uniforms are stored in a covered container until removed for laundering.	Yes/No	
✓	Appropriate protective clothing is available and in use when working with radioactive materials.	Yes/No	
✓	Respirators are provided when necessary, and selected on the basis of hazard present.	Yes/No	
✓	Respirators are used correctly, cleaned after every use and stored in a convenient, clean and sanitary area.	Yes/No	

IV. Hazard Communication

		Yes/No	Comments
✓	Primary & secondary chemical containers are labeled with identity, appropriate hazard warnings, and expiration dates.	Yes/No	
✓	Signs on storage areas (e.g. Refrigerators) and laboratories are consistent with hazards within.	Yes/No	
✓	MSDS binders are available for chemicals used and stored in area.	Yes/No	
✓	Employees know the location of the MSDS binders for their work area.	Yes/No	
✓	Satellite MSDS collections are complete and readily available at all times to labs.	Yes/No	

V. Chemical Storage

		Yes/No	Comments
✓	Incompatible materials are segregated.	Yes/No	
✓	Corrosives and flammables are stored below eye level.	Yes/No	
✓	Hazardous materials used/stored in the laboratory are limited to small quantities.	Yes/No	
✓	Unnecessary, unused, or outdated materials are removed from laboratories and chemical storage areas.	Yes/No	
✓	Safety carriers are available and **in use while transporting chemicals.**	Yes/No	
✓	All lab carts have side-rails.	Yes/No	
✓	All containers are properly labeled with: **Name, Date, Contents, Lab #**	Yes/No	

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VI. Flammable Liquids Storage & Handling

	Yes/No	Comments
✓ Flammable liquids are stored and used away from ignition sources.	Yes/No	
✓ Bulk quantities of flammable liquids are stored in approved storage cabinets.	Yes/No	
✓ Flammable liquid storage cabinets are properly labeled.	Yes/No	
✓ Flammable liquid storage cabinets close properly.	Yes/No	
✓ Flammables stored on open shelves in glass or plastic containers are within permissible quantities (limit =)	Yes/No	
✓ Safety cans used to handle small quantities of flammable liquids are properly labeled.	Yes/No	
✓ Solvent waste cans are labeled properly with: **Name, Contents, Lab #**.	Yes/No	
✓ Nothing is stored on top of flammable cabinets.	Yes/No	

VII. Compressed Gas Cylinders

	Yes/No	Comments
✓ Gas cylinders are properly chained/secured.	Yes/No	
✓ Cylinder caps are in place when cylinders are not in use or being moved.	Yes/No	
✓ Gas cylinders are transported on a cart with chains.	Yes/No	
✓ Gas cylinders are stored away from excessive heat.	Yes/No	
✓ Fuel gas cylinders are at least 20 feet away from oxygen cylinders.	Yes/No	
✓ Gas cylinders are properly marked as to their contents.	Yes/No	
✓ Full and empty cylinders are stored separately.	Yes/No	
✓ Empty gas cylinders are labeled “EMPTY”.	Yes/No	
✓ Gas lines, piping, manifold, etc. are labeled with the identity of their contents.	Yes/No	
✓ Hoses, tubing and regulators are in good working condition.	Yes/No	

VIII. Waste Handling: Hazardous, Non-Hazardous & Biological

	Yes/No	Comments
✓ No liquid waste is disposed of in the sinks or the sewer.	Yes/No	
✓ Hazardous wastes are not accumulated for longer than one month in the laboratory.	Yes/No	
✓ Waste streams are separated as necessary: ex. Solid vs. liquid, hazardous vs. non-hazardous, halogenated vs. non-halogenated, etc..	Yes/No	
✓ Waste containers are appropriately tagged before placing in waste room.	Yes/No	
✓ Containers of hazardous waste are labeled properly with the date and name of person discarding waste.	Yes/No	
✓ **Biological waste** is appropriately marked with a biohazard symbol.	Yes/No	
✓ Syringes and other sharp waste are disposed of into a sharps container and placed directly into biohazard waste container.	Yes/No	
✓ Waste material is not allowed to accumulate on the floors, in corners or under shelves/tables in laboratories.	Yes/No	
✓ **Radioactive waste** is properly marked with radiation symbol.	Yes/No	

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IX. Means of Egress and Emergency Exits

	Yes/No	Comments
✓ Exits are clearly marked.	Yes/No	
✓ Exits are free from obstruction.	Yes/No	
✓ All fire doors are self-closing.	Yes/No	
✓ All fire doors are kept closed.	Yes/No	
✓ Fire alarms are provided.	Yes/No	
✓ Telephones are labeled with emergency numbers.	Yes/No	
✓ Emergency evacuation routes are clearly posted.	Yes/No	
✓ Emergency evacuation routes are posted in common hallways.	Yes/No	
✓ Emergency exit lights are working and clear of obstruction.	Yes/No	

X. Safety Equipment

	Yes/No	Comments
✓ Safety showers and eye wash stations are located within 75' of all laboratories.	Yes/No	
✓ Safety showers and eye wash stations are clearly labeled, and these areas are clear from obstruction.	Yes/No	
✓ All showers and eye wash stations are clean, covers are replaced and they in good working condition.	Yes/No	
✓ Fire extinguishers are available.	Yes/No	
✓ Fire extinguishers are the appropriate type for the hazard in the work area.	Yes/No	
✓ Fire extinguishers are checked monthly. Date of last check: _____	Yes/No	
✓ Fire detection devices, smoke alarms, sprinkler systems, lighted exit signs are in good working condition.	Yes/No	
✓ First-aid supplies are readily available and clearly visible.	Yes/No	
✓ Spill team list is clearly posted in laboratories.	Yes/No	

XI. Other Labeling & Posting

	Yes/No	Comments
✓ Warning signs and labels are present whenever required (e.g. carcinogen, mutagen) where chemicals are stored.	Yes/No	
✓ "No Smoking" signs are posted in prohibited areas.	Yes/No	
✓ "Caution- Radioactive Material" signs are posted on doors of all authorized laboratories, and on refrigerators/freezers where materials are stored.	Yes/No	
✓ Biohazard symbols are posted on access doors to biohazard laboratories and animal rooms and on potentially contaminated equipment.	Yes/No	

XII. Miscellaneous & Notes

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Science Room Safety Contract

I, _____, agree to follow these safety rules while participating in science class this school year:

Read all instructions for a given laboratory activity before coming to class.

Follow all instructions given by the teacher for carrying out the laboratory activity.

Keep your work area clean and tidy.

Know where the eyewash and other safety equipment is located, and how to use it.

Wear safety goggles, apron, gloves, or any other protective apparel assigned by the teacher.

Behave responsibly. Horseplay has no place in the laboratory.

_____ _____

Student Signature Date

_____ _____

Teacher Signature Date

_____ _____

Parent Signature Date

_____ _____

Parent Signature Date

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Laboratory Safety Agreement

Students will be responsible for:

Dressing in a manner that will not cause injury to themselves or others.

Behaving in a manner that will not cause harm to themselves or others.

Following all designated safety rules.

Completing pre-lab activities that will allow them to work safely in the laboratory

I, _____, have read and understand all safety rules
(student name)

discussed for this procedure. I will follow these rules and the procedures for this activity exactly as they are written.

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Chemistry Agreement and Lab Safety Contract

In order for the laboratory to provide a safe and purposeful environment, I understand that I must:

1. Prepare for class by reading the assigned material and bringing the appropriate materials to class as per the class syllabus.
2. Spend time as soon as possible after class reviewing notes and completing any written assignments.
3. Arrive in lab with my notebook completely prepared for the experiment I am about to do. I will always prepare my lab notebook using a blue or black ball-point pen. I understand that if I am not prepared, I may not be permitted to do the experiment and may be assigned a grade of zero. If repeated offenses occur, I will be disciplined in an appropriate manner.
4. Keep an up-to-date, organized notebook for notes, assignments, returned lab experiments, handouts, and other class materials, and make it available to the instructor for inspection at any time.
5. Make up all work from any absence according to school policy.
6. Turn in the original copy of all lab work on the second day after the lab is completed.
7. Understand that contact lenses can a safety hazard if worn in lab, and agree to wear them at my own risk, assuming all responsibility for any injury resulting from my decision to wear them.
8. Read and follow all safety rules on my lab safety handout. Violations will be handled appropriately.
9. Perform absolutely no unauthorized procedures or variations on given procedures, and understand that doing so will result in serious disciplinary action.
10. Follow scrupulously any supplementary instructions given by the instructor either before or during a lab activity.
11. Check the equipment in my drawer and be sure everything is there at the beginning and the end of the lab period, understanding that I am financially responsible for loss or breakage.
12. Ask for assistance from the instructor at any time I feel that I need it.

The top portion is to be pasted into the front cover of the lab notebook before beginning any lab work. The bottom portion is to be signed by the student and a parent or guardian and returned to Mrs. Lee before beginning any lab work.

I agree to abide by this contract so that I may enjoy a safe and successful year.

_____ _____

Date Student signature

I have read the above, including pages 4-8 of the student lab manual, understand that the above student accepts the responsibilities and challenges associated with this class.

_____ _____

Date Parent or Guardian

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Chemistry Safety Rules

Chemistry is a laboratory science class. During the course of the year, you will do many laboratory activities. Although we attempt to make each laboratory as safe as possible, there is always risk associated with these activities. To ensure the safety of you and every other student, the following rules will be strictly enforced. Failure to abide by these rules could result in your removal from the class.

You and a parent or guardian must sign a safety contract that states you have read and agree to abide by these rules before you will be permitted to participate in any laboratory activity. Keep this paper in your notebook for future reference.

General rules

1. The science laboratory is not a place for dangerous or frivolous behavior. You may endanger other students by running, jumping, pushing, etc. Therefore, you must behave in a cautious and responsible manner during all laboratory activities.
2. You must provide your teacher with information about known medical conditions (including allergies, medication, contact lenses) and a daytime phone number where a parent or guardian can be reached.
3. Eating, drinking, chewing gum, and applying cosmetics are strictly prohibited in the chemistry lab.
4. Report all accidents to your teacher immediately, no matter how minor they may seem.
5. You must follow written and verbal instructions explicitly and carefully. Use only materials and equipment authorized by your teacher. Perform only procedures and activities authorized by your teacher. Do not perform any activity unless your teacher is present.
6. Clothing should be appropriate for laboratory work: roll up long sleeves; remove bulky outer clothing and jewelry; do not wear shorts or open-toed shoes.
7. You are responsible for knowing the location and proper use of the following safety equipment: fire extinguisher, fire blanket, emergency shower, eyewash, gas and water shut-off valves, telephone, fume hood.
8. You are responsible for knowing all room exits and evacuation procedures. In case of an emergency, evacuate the lab immediately by the safest exit.
9. Never work in the lab unless the instructor is present.
10. Never remove lab equipment or chemicals from the lab.

Preparation for laboratories

1. Prepare for each activity by preparing your notebook, including the chemical data table and safety hazards, before starting any experiment. If you are in doubt about a procedure, ask for help.
2. Do not touch any materials or equipment until given specific instructions to do so.
3. Your teacher will explain procedures and equipment as needed. Pay particular attention to use of new equipment, changes in procedure, specific chemical safety guidelines, and disposal of used chemicals.

When working with equipment

1. Laboratory equipment is expensive and difficult to replace. You are responsible for checking out and returning equipment, and financially responsible for any damage occurring to that equipment.
2. When you enter the room at the beginning of the period, do not touch any equipment until you are instructed to do so.
3. Understand the operation of equipment before attempting to use it. If there is any doubt, ask your teacher.
4. Do not use glassware that is broken or cracked. Dispose of broken glassware in the specifically designated container.

When working with chemicals

1. Do not touch or smell chemicals unless specifically instructed to do so by your teacher. Never taste chemicals in the laboratory.
2. You must wear safety goggles when working with chemicals or glassware. You will be told when this is necessary.
3. Carefully read--and then reread--chemical labels before using them to ensure that you are using the correct chemical.
4. Use only the instructed amount of each chemical. To avoid contamination, do not return excess chemicals to the stock bottle.
5. Keep your hands away from your face (especially eyes and mouth), and wash them thoroughly with soap before leaving the classroom.
6. If you wear contact lenses, you should consult your doctor about potential problems. Contact lenses can absorb vapors and cause eye irritation. They are also difficult to remove in case of injury.
7. Know the correct procedure for mixing acid solutions. Always add acid slowly to water. Never add water to a large amount of acid.
8. Handle toxic or combustible gases only under the direction of your teacher. Use the fume hood when such materials are present.
9. Your teacher will give specific directions for disposal of each chemical. Do not dispose of solid chemical waste along with ordinary trash. Do not automatically pour liquids down the sink.

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When working with flames

1. Note the location of the gas shut-of valves, fire extinguisher and fire blanket before lighting a Bunsen burner.
2. Exercise extreme caution when using Bunsen burners. Keep your hands, hair and clothing away from open flames. The most common injury in high school labs is burned fingers.
3. Long hair must be tied back when using any open flame (this includes boys).
4. Never use flammable materials near open flames (including paper and solvents).
5. When heating a substance in a test tube, be careful not to point the mouth of the test tube at another person or yourself.
6. Turn off Bunsen burners when not in use.

Housekeeping details

1. Only lab instructions and data tables are permitted in your work area.
2. Keep your work area clean and tidy. Wipe and dry your work bench or table before leaving the laboratory.
3. Return glassware, materials, and equipment to its proper place before leaving the classroom. Be sure glassware is clean.
4. Do not throw trash or other objects in the sinks. Use the trash cans.
5. Keep flames, water, and chemicals away from computers and their keyboards.

First Aid in the Laboratory

+ Report all injuries and emergencies to your teacher immediately.

Emergency	**Safe response**
burns	flush with cool water
cuts and bruises	wash with soap and water, cover with a bandage; do not expose open wounds to chemicals
fire	wrap a person in fire blanket; use fire extinguisher on flames
splash in eyes	flush with plenty of water in eye wash
spills on skin or clothing	flush with water or safety shower
spills on workbench	apply baking soda or kitty litter to neutralize or absorb; clean with paper towel; rinse with clean water
allergic response	go outside for fresh air
poisoning	note the suspected poisoning agent

Eye Safety **This symbol appears in procedures when a danger to the eyes exists. Safety goggles must be worn when this symbol appears.**	Disposal Alert **This symbol appears in procedures when care must be taken to dispose o materials properly.**
Chemical Safety **This symbol appears in procedures when chemicals used can cause burns or are poisonous if absorbed through the skin.**	Thermal Safety **This symbol appears in procedures a a reminder to use caution when handling hot objects.**

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