Safety in Science Teaching

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NOTICE TO THE READER

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Safety in Science Teaching can be found in a PDF file on the Virginia Department of Education's Web site at http://www.pen.k12.va.us.

The intent of this document is to support, not supplant, local School Board policy, which may vary from these recommendations. The use of the more restrictive policy will provide the greatest degree of safety for your school environment.

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CHAPTER I
THE NEED FOR SAFETY

School administrators and teachers want to create the safest learning environment possible. Each is dedicated to the premise that no action will be taken to jeopardize the health or safety of any student. Determining appropriate action to maintain a safe environment requires knowledge of the risks involved in each instructional and school activity. The information presented in this document was developed from the collective experiences of teachers, administrators, health department officials, and industrial safety specialists. The manual was developed to provide a summary of safety information relevant to public school teachers and administrators. The information provided can serve as the foundation for safety policies for a school or division.

A safe environment can be created through a process involving the following steps: (1) anticipating hazards, (2) recognizing hazards, (3) eliminating hazards, and (4) controlling hazards. Each of these steps can be approached through a focus on categories of hazards found within the school environment. High-risk activity categories usually found in the school environment include the following:

1. Recreational activities on the playground, school grounds, and athletic fields
2. Competitive athletic events
3. Physical education activities
4. Science laboratory
5. Other laboratories and shops
6. Student errands and extra-curricula activities
7. Off-campus learning activities (field trips)

The school science program involves a large percentage of these high-risk activities. Science activities are diverse and are more difficult to supervise than the traditional classroom lecture setting. In addition, the environment in a science classroom will contain more potentially hazardous material and equipment.

A science safety policy can be a major factor in creating a safer environment for the science program, especially if it is part of a larger plan encompassing all high-risk areas of the school.

Responsibility for Safety

Ignorance, carelessness, and apathy are contributing factors in most accidents and exposure to health hazards. The Occupational Health and Safety Act of 1970, as amended in 1990, has greatly increased public awareness of health and safety issues. Medical, health, and other professional organizations have provided information on specific hazards. To alleviate carelessness and apathy, each person involved in an activity must have a vested interest in his/her own personal safety and the safety of those around them.

The Administration

Each school board, superintendent, supervisor, and principal is responsible for the safety of all who work, study, and visit school buildings. Public confidence in the school as a safe facility is necessary to its operation. A safe school system will have a low frequency of injuries and only minor property damage during a school year. Therefore, all school administrators and board members should be involved in developing policies to assure a safe and healthful school environment.

The Teacher

Each teacher should assume responsibility for assuring that the teaching space is as free of safety and health hazards as possible. This means teachers must be continuously vigilant in recognizing unsafe conditions and eliminating or reporting such conditions to the school administration. Ignorance, carelessness, or apathy can result in personal injury that may lead to litigation.

The Student

Students have a responsibility to follow all safety instructions presented by the teacher and to abide by classroom/laboratory rules of conduct. The older the students the greater is their responsibility for contributing to the safe and healthy facilitation of classroom activity. Students should conduct themselves in such a manner as to reduce the probability of being involved in accidents and incidents.

The Elementary Program

Safety in the science program must begin as early as possible. Elementary school teachers and principals need to pay close attention to the rules, guidelines, procedures, and safety procedures in this handbook. The chapters that deserve full attention are: Chapter I, The Need for Safety; Chapter III, Hazard Recognition; Chapter IV, Planning for Safety; Chapter VI, Biological and Environmental Hazard Control; Chapter VII, Other Hazards and Control Procedures; and Chapter IX, Documentation. As an additional reference you may refer to the *NSTA Pathways to the Science Standards* Appendix C (1997) available from NSTA. It would be beneficial for each school to have at least one of these manuals per building.

Teachers should pay close attention to the following sections of other chapters. Chapter II, Assessing Needs (The Safety Inventory and the Activity Inventory); Chapter V, Chemical Hazard Control (Environmental Protection, Storage, and Additional Storage Considerations); Chapter VIII, Eye, Face, and Respiratory Protection (Eye Protective Devices, Management Procedures); and Chapter X, Designing for Safety (Storage Space).

CHAPTER II
ASSESSING NEEDS

Anticipating, recognizing, identifying, eliminating, and controlling hazards and hazardous activities require that one know what to look for and where to look for it. It is imperative that learning environment safety assessments be made on a regular basis. Complete inventories are recommended as an appropriate means of initiating this task. Three types of inventories are suggested for assessing safety needs--the chemical inventory, the activity inventory, and the safety equipment inventory.

The Chemical Inventory

Science teachers and building administrators should be aware of which chemicals are in the school. A chemical inventory must be completed at least once a year to be useful. The chemical name of the substance and the amount on hand should be listed. It is also important that the inventory state the storage location for each chemical. Additional information necessary for the inventory includes: (1) purchase date of the chemical, (2) name of supplier, (3) potential hazards, (4) program in which used, and (5) a Materials Safety Data Sheet (MSDS) for each chemical maintained. The chemical inventory should be computerized for ease of adding or deleting information.

This type of inventory allows for rapid identification of a chemical's hazards. As an example, the release of information identifying a newly documented carcinogen could be handled quickly through an inventory reference. One should not have to search through the laboratory and stockroom to determine if the carcinogen is present.

The Safety Inventory

The safety inventory involves an assessment of the safety features of the laboratory and should include the number, location, and type of the following equipment and facilities:

1. Fire extinguishers (including sand)
2. Fire blankets
3. Lockable master controls, and emergency controls for all utilities
4. Fume hoods
5. Eye safety devices (goggles, face shields)
6. Exits (two per laboratory)

7. Safety shields
8. Protective clothing (aprons, thermal and rubber gloves, laboratory coats)
9. Deluge showers
10. Eye wash fountains
11. Appropriate waste containers (chemicals, biological, broken glass)
12. Lockable chemical storage area
13. Lockable, vented flammables cabinet
14. Lockable, vented corrosives cabinet
15. Dust masks
16. Hearing protection
17. Spill response equipment
18. Ground Fault Interrupter protected circuits
19. Safe chemical transporters (rubber buckets)

Each safety device included in this inventory should be fully operational. A malfunctioning piece of safety equipment will be useless in an emergency. The absence of appropriate safety equipment will necessitate the elimination of some instructional experiences.

The Activity Inventory

This inventory covers three categories of student activities in the science department: (1) formal student activities (regular laboratory experiments), (2) informal or enrichment activities (projects, science fair experiments, home assignments), and (3) field trips.

1. The formal student laboratory inventory should include:
   1) A list of all laboratory activities scheduled for each science course
   2) A brief description of the procedures involved in conducting the activity
   c) A list of chemicals and equipment necessary to conduct each activity
   d) A list of all cautions or safety statements included in the text and laboratory manual
2. The informal enrichment activities section inventory should include:
   1) A list of science projects or types of projects that will be sponsored by department personnel
   2) A statement of rules or regulations governing the construction or production of student projects
   3) A definition of the working environment in which the student prepares the project (laboratory project room, home basement, etc.)
   4) A list of the chemicals, materials, and equipment available for students

3. The field trip inventory should include:
    1) A list of field trips by subject area
    2) A concise description of the environment for specific field trips (example, biology - natural area studies)
    3) A list of equipment to be used on field trips (i.e., rock chipping hammers)
    4) A statement of rules or regulations governing student conduct on field trips
    5) A list of potential hazards on field trips

These inventories can serve as a starting point for promoting awareness of the importance of safety. A comprehensive evaluation of the type and condition of the laboratories and classrooms is an invaluable aid to reaching safety goals. This should include an appraisal of class size relative to the teaching space available, the arrangement of student stations, condition and availability of services, and scheduling procedures. This information, once assembled, should be evaluated annually to determine whether hazardous materials or conditions exist.

CHAPTER III
HAZARD RECOGNITION

Hazards can be classified into two broad types—physical and health. Physical hazards are those that can result in direct and immediate bodily injury. Hazards such as fires, explosions, falls, cuts, burns, or poisonings are in this category. Health hazards are those that may lead to chronic health problems such as cancer, birth defects, nerve damage, tissue damage, or other health impairments either immediately or years after the person is exposed to them. Exposure to health hazards may be accidental but are often the result of ignorance that the hazard exists.

Physical Hazards

Some physical hazards can exist in most environments. The instructional environment must be constantly examined for conditions that can result in injury due to tripping, fires, or falling objects, for example. Other conditions may result from the specialized nature of equipment and materials such as those existing in science and other laboratories. In public schools, one of the areas with the greatest potential for injury from physical hazards is the science laboratory. Overcrowded laboratory areas, lack of appropriate safety equipment and facilities, and lack of science training for middle school and elementary teachers tends to increase the hazards in science programs.

To recognize potential and existing hazards, one must: (1) identify student or teacher activities that have a high probability of leading to injury, (2) identify equipment, materials and chemicals that are capable of causing injury when misused, and (3) identify the potential injuries which may result. Some injuries that may result from physical hazards are described in the next section.

Injuries due to impact are caused by a collision between a person and an object or objects. Causes of such impacts are falls, falling objects, explosions, implosions, and propelled objects.

Falls - These can be caused by faulty equipment including stairs, ladders, and step stools; chemical spills; or by hazardous activities such as climbing on chairs or inappropriate play. Falls may also result from ill placed extension cords, equipment placed in walk-ways, and other conditions that provide a tripping hazard.

Falling objects - These include precariously balanced objects stored on a table or high shelf, loose rocks, and tree limbs.

Explosions - The three common sources of explosions are rapid chemical decomposition of an unstable substance, rapid chemical combination of one or more substances, and the rupture of a pressurized container. Substances that can cause explosions by rapid decomposition are normally labeled "explosive."

The violent chemical reaction of two or more substances is easy to recognize. However, since the hazard arises only when the materials are mixed, the individual material often carries no apparent warning. The term "incompatible chemicals" may be used to identify these substances.

Any container that is used for holding a substance under pressure can explode. Heating a substance in a closed container or any act that increases pressure in a container can result in an explosion. Refer to the Material Safety Data Sheet (MSDS) for specifics on each substance. Additionally, some explosive substances are identified in the appendix. **Use of safety shields is strongly recommended**.

Implosions - An activity that creates a vacuum within a container made of non-ductile material is hazardous. Rapid contraction of a brittle material (red-hot glass, ceramic, or rocks rapidly cooled) can cause the material to implode. Activities that create a vacuum should be conducted using approved vessels. **Use of safety shields is strongly recommended. Never use an explosive reaction or explosive materials to illustrate volcanic action**.

Propelled objects - This category includes all objects set in motion by means other than gravity, explosions, or implosions. Elastic materials (springs and rubber bands) that are used to propel objects in many physics and physical science experiments are potentially hazardous. The potential for student misuse (horseplay) of the materials used for these experiments should be considered. Activities that allow students to use objects that can be easily thrown (rubber stoppers, etc.) are also potential hazards. **Use of safety shields is strongly recommended.**

Thermal Burns - Hazardous activities that cause thermal burns include heating liquids, melting glass for bending and shaping, and using laboratory heat sources. All flammable

liquids should be considered as potential sources of severe burns. A flammable liquid is defined by the National Fire Protection Association as any liquid having a flash point below 100°F. When in doubt about the flammability of a substance, consult the MSDS for the chemical in question.

Chemical Burns - Strong acids (sulfuric, nitric, hydrochloric, and acetic) and bases (sodium hydroxide, potassium hydroxide) are frequent sources of chemical burns. Phosphorus, phenol, iodine, and alkali metals can also cause chemical burns when allowed to contact tissue.

Cuts and punctures of the skin may result from the students' exposure to glass (tubing, thistle tubes, broken containers) and dissection equipment (scalpels, razor blades) used in instruction. Infection of these wounds is also a hazard. However, the greatest hazard presented by open wounds is exposure to bloodborne pathogens, for which the district is required to have a specific policy.

High voltage equipment and standard 110-120 volt circuits are common sources of electrical shock. Hazards include exposed conductors, frayed insulation, faulty grounding circuits, and overloaded circuits. Hazardous activities include making an electrical contact while exposed to conducting fluids, such as using wet hands to plug equipment into a receptacle.

Injuries to the respiratory and central nervous systems can result from inhalation of toxic gases, fumes, and dust particles. Hazardous chemicals are normally labeled "caution-avoid inhalation of fumes." Examples are chloroform, ethers, chlorine, and toluene. Activities that generate toxic inhalants, such as carbon monoxide, carbon dioxide, hydrogen sulfide, oxides of nitrogen and chlorine, are also hazardous. All gases used or generated in science laboratory activities should be controlled with the appropriate traps, ventilation, or evacuation systems.

Poisoning causes internal injuries ranging from reduced functioning of the central nervous system to severe irritation of the gastrointestinal tract. Substances capable of causing these injuries should be labeled "POISON." An activity in which a student could accidentally swallow one of these substances is hazardous. Chemical spills should be cleaned up using the appropriate methods and materials as indicated in the MSDS.

NOTE: THE USE OF MERCURY OR MERCURY COMPOUNDS IN ELEMENTARY, MIDDLE, AND SECONDARY SCHOOLS SHOULD BE AVOIDED.

Health Hazards

The identification of the cause of a health hazard injury is difficult, since the injury may go unnoticed for years. A substantial body of information is available with lists of known health hazards. The appendix contains a list of chemicals that are the most widely publicized health hazards.

Carcinogenic chemicals are the most widely publicized of the health hazards. In August 1976, the Occupational Safety and Health Administration (OSHA) published a list of thirteen carcinogenic chemicals. These chemicals should not be used in public school science programs:

1. Acetylaminofluorene - believed to cause cancer in humans
2. 4-Aminodiophenyl - bladder cancer
3. Benzidine (and its salts) - bladder tumors
4. Bis-chloromethyl ether - lung cancer
5. 3,3'-Dichlorobenzidine (and its salts) - believed to cause liver, bladder, and breast cancers
6. 4-Dimethylaminoazobenzene - suspected cause of cancer in humans
7. Beta-naphthylamine - bladder cancer
8. 4-Nitrobiphenyl - bladder cancer
9. N-nitrosodimethylamine - suspected to cause human cancer
10. Beta-propiolactone - believed to cause cancer in humans
11. Methyl chloromethyl ether - believed to cause lung and sub-skin cancers
12. Alpha-naphthylamine - has been implicated in human bladder cancer
13. Ethyleneimine - causes cancer in animals

Other health hazards can lead to the development of birth defects, chronic heart diseases, chronic lung disorders such as emphysema and black lung, liver and kidney damage, and dysfunction of the central nervous system. Among these extreme health hazards are mercury, carbon tetrachloride, benzene, and carbon disulfide. The use of these chemicals in public schools should be completely avoided.

1. Mercury vapor and the dust of mercury compounds are absorbed through the skin and the membranes of the respiratory tract. Chronic mercury poisoning affects the central nervous system and is manifested by muscle tremors, spasms, personality changes, irritability, and depression.

c) Carbon tetrachloride is toxic by inhalation, ingestion, or skin absorption. Liver damage is the most frequently sustained injury, but kidney damage and visual disturbances also occur.
d) Carbon disulfide is toxic through ingestion, inhalation, or skin absorption. Psychic disturbances may result from long-term exposure.
e) Benzene is most toxic by inhalation and skin absorption. The inhalation of benzene vapor can result in damage to the bone marrow. Narcosis and dermatitis has resulted from absorption of benzene through the skin.

The first step in controlling health hazards is to determine the types and amounts of hazardous chemicals on hand. A comparison of the school's chemical inventory with the published lists of chemical hazards must be used. The second step is to identify activities and/or environmental conditions by which a student may be exposed to the hazard.

In addition to chemical health hazards, there are biological and radiological health hazards. These are discussed further in Chapter VI, "Biological and Environmental Hazard Control," and Chapter VII, "Other Hazards and Control Procedures."

Hazard Alerts

The National Fire Protection Association, Avon, Massachusetts, uses the NFPA 704 System to rate three different types of hazards on a numerical scale described below.

RATING HEALTH HAZARD	FLAMMABILITY	REACTIVITY
4 Extreme Health Hazard	Extremely	Extremely
3 High Health Hazard	Highly	Highly
2 Moderate Health Hazard	Moderately	Moderately
1 Slight Health Hazard	Slightly Combustible	Slightly
0 No Significant Hazard	Noncombustible	Nonreactive

Since research on the health hazards associated with human ingestion of chemicals is a continuous activity, it is imperative that science teachers, especially chemistry teachers, maintain an awareness of current information regarding the hazards of all chemicals used in school science activities.

CHAPTER IV
PLANNING FOR SAFETY

Each school division should implement a safety policy. Procedures for implementing the safety policy should include assigning responsibility to staff; providing an annual training program; determining acceptable parameters of student conduct; developing procedures for the procurement, storage, handling, and use of hazardous materials; implementing a system for inspection and maintenance of facilities and equipment; and adopting appropriate post-accident procedures. Guidelines for planning should emphasize selecting instructional activities that minimize hazards. These guidelines also should direct the teacher in the selection, substitution, or modification of learning activities and instructional procedures to improve safety.

The Planners

The building principal, department chairpersons, chemical hygiene officers (as required by OSHA standard 1910.1450, 1991) and classroom teachers must take the major responsibility in planning for safety. Central office staff, patrons, and safety and/or health consultants also should be involved in the development, implementation, and oversight of the school division's safety program.

Assignment of Duties

The building principal or appropriate personnel should:

a) Provide for the proper maintenance or replacement of facilities and equipment to insure the health and safety of students
b) Develop emergency procedures that designate an office contact person, provide proper supervision for any class in which the teacher has been distracted by an accident, and make competent medical assistance available
c) Ensure that appropriate instructional techniques and curricular materials are used by the faculty
d) Provide, with the assistance of the faculty, alternative educational experiences for students whose conduct pose hazards
e) Implement annual safety training

The department chairperson or appropriate personnel should:

Ensure that appropriate inventories are accomplished and made available to all teachers and administrators

Coordinate all purchases to insure that orders are not duplicated, that only the amount of a chemical necessary for a one year program is ordered, and that extremely hazardous materials are not ordered

Record, transmit, and follow up all requests for maintenance or replacement of equipment

Assist and support the classroom teacher in determining maintenance needs

Assist and support the classroom teacher in modifying teaching strategies when necessary to improve laboratory safety

Ensure that appropriate safety equipment is in place, storage facilities are appropriately organized and functioning properly, and approved safety practices are shared with all teachers

Coordinate and provide documentation for an annual safety training

The classroom teacher should:

a) Model safe classroom procedures
b) Instruct students about the potential hazard(s) of an activity and the appropriate procedures for safely completing the activity
c) Ensure that all equipment used by students is functioning properly
d) Ensure that student activities are appropriate for their background and maturity and that safety equipment and facilities are available
e) Utilize appropriate classroom management techniques to reduce the risk of student exposure to potential hazards
f) Ensure that all students follow instructions, utilize appropriate procedures, and practice safe behavior
g) Participate in annual safety training
h) Not assign students responsibility for making stock solutions or performing unsupervised demonstrations

Parameters of Student Conduct

School division standards for student conduct specified by the *Regulations Establishing Standards for Accreditation for Public Schools in Virginia (8 VAC 20-131-260 and 8 VAC 20-131-210)* should include the necessary parameters for safe conduct in the science program. The achievement of an atmosphere free of threat to person or property should include the absence of any threat due to safety hazards.

Specifically, the standards of conduct should:

1. Specify that safety instructions are to be expressly followed
2. Direct the wearing of safety equipment and specify the conditions in which the equipment must be worn
3. Specify that shoving, fighting, deliberate use of unauthorized chemicals or materials, or other behavior that could cause injury to persons are forbidden
4. Provide for the removal of students from laboratory or field study if their conduct threatens other students involved in these activities
5. Specify additional rules of conduct as may be necessary to safely implement a defined program of study

Procedures for Procurement, Storage, Handling, and Use of Hazardous Materials

These procedures should specifically deal with the hazardous materials that are essential for conducting the school's science program. Specific guidelines for chemical hazard control procedures are discussed in Chapter V.

Post-Accident Procedures

Post-accident procedures should include emergency procedures, procurement of medical assistance, and documentation in accordance with local school board policy.

1. Emergency procedures are those actions taken immediately following an accident to lessen the severity of injuries. Faculty members should be aware of the types of hazards present and anticipate the types of accidents that could occur in a specific laboratory situation. Suggested procedures for assisting accident victims are outlined in Chapters V, VI, and VII. Drills on emergency procedures should be conducted for high probability accidents.

a) Procurement of medical assistance should relate specifically to the medical assistance available to the school. The plan should include:
   a) The designation of a school office contact person and an approved procedure for contact
   b) A medical form for each student specifying that the contact person has parental permission to refer the student to a designated medical authority
   c) A procedure for immediate notification of parents or guardian.

d) The designation of appropriate transportation to a medical facility when needed, such as rescue squad or ambulance service.
   2 Documentation should include the development of and procedures for completing an accident report form. Accident reports are discussed more extensively in Chapter IX.

Guidelines for Classroom Planning--Modification of Curriculum and Instructional Strategies

If an essential curriculum objective must be met within a facility that lacks safety equipment, either the objective or the conventional instructions (as specified in textbooks or laboratory manuals) should be modified. The means of modification may include:

1. Substituting a less hazardous material for a high risk material
2. Substituting a similar chemical reaction that poses less risk
3. Having hazardous components of an activity conducted only by the teacher
4. Conducting teacher demonstrations in lieu of student activity
5. Substituting multimedia presentations for the hazardous activity
6. Substituting computer simulation for extremely hazardous chemical experiments
7. Utilizing smaller amounts of chemicals such as microscale laboratory activities

It is suggested that these modifications be incorporated into the appropriate local curriculum.

CHAPTER V
CHEMICAL HAZARD CONTROL

Chemical reagents must be used with caution. Reagents may be explosive, combustible, poisonous, caustic, or corrosive, and exposure to some may cause a deterioration of health over a period of years. Chemicals can also pose a great hazard in storage. Chemical hazard control should be a total program that includes purchasing, record keeping, storage, use, disposal, and continuous training.

Purchasing

A well coordinated purchasing program should insure an adequate supply of essential chemical reagents while screening out nonessential or highly hazardous chemicals. A staff person should be designated to coordinate all purchases. This person should:

1. Be capable of assessing the hazards of chemicals
2. Be sufficiently knowledgeable to recognize requests for nonessential chemicals
3. Have a current inventory of existing chemicals available, including their MSDS sheets

A sound policy for purchasing chemical reagents should include these statements:

1. High-risk chemicals should not be purchased if an effective instructional program can be carried out without them.
    a) It should be the responsibility of the purchasing coordinator to assess the hazard of a given chemical.
    b) The science faculty, with the assistance of the building administrator, should reassess the need for any chemical regarded as highly hazardous. Every effort should be made to modify curriculum and instructional procedures to eliminate the need for hazardous chemicals.
    c) Corrosive chemicals should be purchased only in the highest concentration in which they will be used.

2. Chemical reagents should be purchased in quantities consistent with rate of use.
1. Time-sensitive chemicals should be purchased only in quantities sufficient for one year.
2. Chemical purchases should be determined annually based upon: (1) school needs, and (2) a specific chemical shelf life (Reference MSDS). This is recommended for all chemicals but is essential for chemicals with high reactivity or flammability.

3, All orders should be checked to eliminate duplication of purchases.

Record Keeping

Inventories are essential in the control of chemical hazards. An inventory of reagents, safety equipment, and laboratory equipment is needed. It would enable any member of the science faculty to determine the existence of a specific chemical, its location, and its approximate shelf age. Chemical inventory should be taken at least once a year.

The chemical inventory should:

1. Contain the date of the inventory
2. Identify chemical reagents by name and formula
3. Specify the amount of each reagent present and the inventory date
4. Indicate the storage location of each reagent
5. Indicate the course for which the reagent was ordered
    a) Indicate the hazard of each reagent
    b) Record the purchase date, arrival date, and quantity of all reagents received
    c) Record the date of removal of a reagent from stock
    d) Record the location of the MSDS

Inventories of safety equipment and laboratory equipment should enable any member of the science department to quickly determine:

1. Whether appropriate equipment is on hand to control a specific chemical hazard
2. The location and condition of needed equipment

Storage

The storage of reagents is a key factor in controlling chemical hazards. Chemical storage facilities must provide:

1. Security - Unauthorized removal or use of chemicals must be prevented.
2. Environmental protection - Fumes and vapors must be prevented from entering classrooms and laboratories.
3. Fire protection - The chemicals must be protected from fire.
4. Reactivity- Incompatible chemicals should be separated in storage.

An ideal chemical storage system will fulfill all four functions at minimal cost.

Additional Storage Considerations

1. Large containers should be stored on or near the floor.
2. Shelf assemblies should be firmly secured to walls. Avoid free standing, island shelf assemblies.
3. Provide anti-roll lips on all shelves.
4. Reagents that are caustic, corrosive, or volatile should be stored below waist level.
5. Only small containers (one-half liter or less) should be stored on high shelves.
6. No reagent should be stored above eye level.
7. Chemicals should not be stored in work areas or within the fume hood.
8. Food should never be taken into a chemical storage area or stored in a laboratory refrigerator.
9. Flammables may be stored in explosion-proof (all ignition sources sealed) or explosion-safe (interior ignition sources sealed) refrigerators. Standard household refrigerators should never be used in a chemical storage area to store flammables because unsealed electrical circuits can serve as ignition sources. The explosion-safe refrigerator can serve as an ignition source for flammable vapors originating outside the refrigerator and should not be used in a storeroom where such vapors may be present.
10. Acids should be stored in a dedicated flammables cabinet
11. Corrosives should be stored in a dedicated cabinet

Environmental Protection

Fumes and vapors should be removed from the storeroom to a safe area outside the building. A safe area is defined as having:

1) Low probability of fume or vapor re-entry through air conditioning, heating, or ventilation system
2) Low probability of human exposure in the area

Substances that emit fumes or gases should not be stored in an unventilated stockroom. A stockroom that has been closed over a prolonged period such as a holiday should be ventilated before entering. A stockroom should meet the OSHA standards for ventilation (OSHA Standard 30, section 4-4.1.6).

Some fumes and vapors present additional hazards and require additional storage precautions. These include:

1. Corrosive vapors – A corrosion resistant ventilation system should be used. Corrosive vapors and fumes must also be vented to the outside to avoid reaching toxic levels and to prevent the corrosion of metal fixtures and containers. A periodic inspection of chemical containers should be made.
2. Flammable vapors – The vapors from liquids classified as "flammable" form explosive mixtures with air. A "flammable" liquid has a flash point below 100°F. The storage area should be free of all sources of ignition. It should include explosion-proof electrical fixtures (light switches and ventilation fan motor) and warning signs prohibiting the use of open flame in the area. (OSHA Standard 30, Section 4-4.1.6).

Fire Protection

The fire hazard inherent in chemical storage can be controlled through construction and management of the storage facility. Special cabinets are commercially available for the storage of flammables and combustibles. Such cabinets must meet the requirements specified by NFPA-30 (National Fire Protection Agency) and OSHA 1910.106 and be vented to a safe area. A built-in storage facility should also comply with NFPA-30.

Fire hazards can be reduced by:

1) Limiting the amount of flammables and combustibles stored
2) Using safety cans (defined by NFPA-45) for flammable liquids
3) Separating incompatible chemicals

Use of Chemicals

Before beginning a laboratory exercise, know the hazards of the chemicals to be used, appropriate safety precautions, and appropriate emergency procedures.

1. Know your chemicals! Use the activity inventory or laboratory manual to determine the name, type, and amount of chemicals to be used in the experiment. Use the procedure described in Chapter III to determine the hazard potential.
2. Development strategies to compensate for chemical hazards.
    l. All persons in a laboratory in which chemicals are to be used should wear approved eye protective devices and protective clothing (aprons, laboratory coats).
    m. All persons should wear gloves, goggles, and face shields when chemicals capable of severe tissue damage (chemical burns) are to be used.
    n. Body protective devices (laboratory guards, body shields) should be used when an explosion hazard exists.
    o. A properly operating fume hood should be used for all chemical reactions that may generate toxic fumes, vapors, or dusts.
    p. Chemicals that are highly caustic or corrosive should be used only if an eyewash fountain is available and functioning properly.
    q. If highly caustic or corrosive chemicals are to be used in large enough amounts to splash on a major portion of the body, a functioning safety shower should be available.
    r. Double buckets should be used to transport corrosive materials.
    s. Students should be carefully and explicitly instructed in safe procedures, including the nature of the hazard, the proper procedures for conducting the activity, the proper use of the safety equipment, and appropriate laboratory conduct.
    t. Students should be instructed in the proper use of poisonous chemicals.
    u. Students and teachers should never work alone when mixing chemicals.

DO NOT ASSIGN A LABORATORY INVESTIGATION IF EQUIPMENT IS NOT AVAILABLE TO COMPENSATE FOR A POTENTIAL CHEMICAL OR PHYSICAL HAZARD.

3. Procedures for laboratory emergencies should be developed as described in NFPA-45. These procedures should include alarm actuation, evacuation, and first aid for specific types of injuries.
    a) Alarm - actuation-Notify the designated contact person in the school office. The intercom should be used if available. If the accident imperils more than the immediate class, activate the fire alarm system.
    b) Evacuation – The evacuation plan should be written with an accompanying diagram and posted in each laboratory. The evacuation plan should include:
        1) The conditions under which the laboratory will be evacuated
        2) The method of contacting the school office
        3) Action to be taken upon being ordered to evacuate (shut off gas, electrical equipment, close windows and doors
        4) Exit routes including an alternate route

        The person charged with counting of students when the class reaches the designated safe zone
    c) Emergency Action – The plan should specify immediate action to prevent further injury after an accident. The plan should include specific directions for obtaining professional medical services for the injured. The following types of first-aid procedures may be necessary:
        1) Clothing fire – Instruct students in NFPA-recommended procedures until it becomes second nature. The injured party must STOP, DROP to the floor, and ROLL. The other students and teacher must be prepared to push the injured student to the floor and roll that student to smother the flames. Safety showers or fire blankets should be used ONLY if immediately at hand. In all events, NFPA-45 recommends that the student be horizontal to reduce flame damage to face and eyes and to reduce the risk of smoke and heat inhalation.
        2) Laboratory fire – Actuate alarm and evacuate. Use an appropriate fire extinguisher to clear a path for evacuation, to put out small fires, or to prevent fire from spreading. The teacher's primary responsibility is the faety of students.
        3) Chemical splash (eye) – Use an eyewash fountain or appropriate substitute to immediately flush eye with water. Contact the school office. Continue to flush eye for 15 minutes or until medical assistance arrives.

4) Chemical splash (body) – If the chemical is capable of causing chemical burns, wash immediately in a safety shower.

EXCEPTION: Water reactive chemicals require special precautions. Do not expose students to the hazard the use of water reactive chemicals unless preparations have been made to specifically address this hazard.

5) Release of toxic gases – Actuate alarm and evacuate.
6) Electrical shock – Shut off electricity and seek qualified assistance immediately.
7) Ingestion of poisonous chemical – Contact the school office and clinic immediately. Determine the type and amount of poison ingested and make this information available to medical authorities.

Disposal of Chemicals

Chemicals that are no longer used in the instructional program should be removed from the school. Chemicals to be removed fall into three categories:

1. Hazardous chemicals – Those chemicals that pose greater risk than is acceptable. The nature of the hazard (carcinogen, explosive) should be indicated beside the name of the chemical.
2. Unneeded chemicals – Chemicals that are not considered excessively hazardous but that are no longer used in the instructional program.
3. Useless chemicals – Chemicals that are not excessively hazardous but that have been contaminated, aged, or otherwise rendered unusable as reagents.

Virginia science teachers should contact their chemical hygiene officer for proper disposal or recycling of chemicals.

Labeling of Chemicals

1. Proper labeling is fundamental to a safe and effective laboratory operation. Reagents created in the laboratory also require labeling.
2. Purchased materials usually have adequate identification of the material by chemical name. Reagents identified only by common name should also have individual chemical components listed on the label.

3. Precautionary statements are usually but not always included with flammables, corrosives, and reactive or explosive compounds.

ABSENCE OF PRECAUTIONS ON A MANUFACTURER'S LABEL DOES NOT MEAN THE MATERIAL HAS NO HAZARDS

Rules for Making Labels

1. Indicate clearly the working name, chemical name, and chemical formula of the reagent.
2. Indicate the date the reagent was produced or purchased.
3. Indicate hazards and handling precautions.

SAMPLE LOCAL LABEL

-

Fehlings Solution B
(.68M $KnaC_4H_4O_6.4H_2$) 1.6M NAOH)
WARNING – Very Hazardous to Eye

CAUTION – Caustic – Poison
11/3/2000
Prepared by G. Teacher
Lewis High School Biology Department

Commercially available labels are spillproof, easy to use, and are relatively inexpensive. Pressure sensitive labels using the NFPA-704 hazard symbol and space for additional information are preferred.

Chapter VI
BIOLOGICAL AND ENVIRONMENTAL HAZARD CONTROL

Biology, life science, and earth science teachers are confronted with a wide range of hazards. In addition to chemical agents, there are the hazards associated with (a) handling animals and microorganisms, and (b) classroom activities on the school grounds and outdoor study areas. Effective control of such hazards involves: (a) recognition of the hazard, (b) development of control procedures, and (c) development of first-aid measures. Teachers should receive annual training on biological and environmental hazards.

Animals in Instructional Programs

1. Recognition of the hazard
   Animals in the classroom can be hazardous in several ways:
   a) Numerous diseases can be transmitted to humans from animals, some of these can be fatal
   b) Animals may contract and serve as carriers for human diseases
   c) Scratches and bites are hazards when handling animals
   d) Animals can be sources of potentially severe allergies
   e) Animals may adversely impact classroom air quality
2. Control procedures
   Acquisition considerations
   a) Only certified disease-free animals should be purchased from reputable
   b) Firms. The purchase of animals from local breeders or the use of pet animals is not advised.
   c) Purchase only species suited to the learning environment and instructional program. Low food consumption and small physical size should be considered in the selection of an appropriate species.
   d) Permits may be required for securing and/or keeping certain animals. Check local, state, and federal regulations.

3. Animals captured in the wild should not be used in school laboratories.
   Housing specifications
   a) Animal care facilities should be of sufficient size to allow the animals to comfortably perform such natural functions as eating, exercising, and sleeping. The facilities must be sanitary.
   b) Feeding and watering equipment should be selected for ease of cleaning and sanitizing and for suitability for the species.
   c) The facilities should be designed to allow removal of animal waste with minimum disturbance to the animal.
   d) Climatic control (temperature, humidity, and air quality) must be sufficient to provide a humane environment for the animal.
4. Classroom management policies
   a) Appropriate resource organizations and/or reference material should be consulted to ensure that a proper environment is maintained for the animals.
   b) The animals must be fed and their facilities cleaned at appropriate intervals. This schedule must be maintained on weekends and school holidays.
   c) Cages, feeding devices, watering devices, and bedding materials should be sterilized.
   d) Hands should be sterilized before and after any contact with an animal or its environment.
   e) Access to animal care facilities should be limited to those individuals directly responsible for the animals.
   f) The appropriate climate for a species must be maintained at all times.
   g) Animals suspected of being ill should be isolated and given proper care.
   h) People who are ill should not be permitted to handle and care for laboratory animals.
   i) Appropriate protective equipment such as leather or rubber gloves should be worn when handling animals.
   j) Only commercially prepared specimens should be used for dissection.

Microorganisms and Biotechnology

1. Recognition of the hazard
   The primary hazards of working with microorganisms are:
   a) the contraction of an infectious disease
   b) the infection of an open wound
   c) Another hazard includes unknown microbes in cultures. To avoid this potential hazard, only use cultures that are obtained through an established biological supply company.

2. Control procedures
   a) Use only sterile equipment.
   b) Use appropriate handling procedures to ensure that microorganisms are not released into the environment as aerosols.
   c) Instruct students in appropriate procedures, and supervise them to insure proper control of cultures.
   d) Prohibit mouth pipetting.
   e) Prohibit cultures of pathogenic microorganisms.
   f) Treat all agents as if they are pathogens.
   g) Students and instructors should never have anything in their mouth while working with bacterial and viral cultures.
   e) Students and instructors should wash their hands thoroughly before and after conducting laboratory work.
   f) Unsealed but covered containers should be disinfected by autoclave for 0.5 hours at 15 lbs. of pressure or soaked in bleach by flooding with 10 percent bleach for 0.5 hours.
   g) Cultures obtained from soil, mouth, plants, or other local environmental sources should not be used.
   h) Local, state, and federal regulations should be consulted regarding the safe disposal of cultures.
   i) All equipment and work surfaces should be properly cleaned and disinfected.

Blood and Other Body Fluids

The use of human body fluids or tissues is generally prohibited for classroom laboratory activities. See OSHA Standard 1910.1030 for detailed explanation of the dangers and precautions involving body fluids.

Field Study

1. Recognition of the hazard
   Injuries due to (a) impact, (b) cuts and punctures, (c) poisoning, and (d) allergenic reactions are most commonly encountered in field study activities.

2. Control procedures
   a) The instructor should conduct a survey of the study area. The survey should include a list of all hazards including:
      1) Conditions that may cause students to fall (steep terrain, slippery or unstable rocks)
      2) Unstable objects overhead, which may fall onto students
      3) Animal burrows or holes into which students could step
      4) Footbridges or other elevated crossings that may collapse under student weight
      5) Deep water or streams with currents strong enough to sweep a student off balance
      6) Animals capable of attacking and injuring students
      7) Poisonous, venomous, and infected animals
      8) Insects and arachnids
      9) Allergenic and poisonous plants
      10) Vehicle traffic
   b) Take precautionary measures such as:
      1) Mapping the safest passage through the study area
      2) Confirming that all students are physically capable of participating in the field study (heart condition, severe allergenic reactions, and ambulation difficulties must be considered)
      3) Obtaining permission from parents for children to be involved in studies off the school grounds
      4) Avoiding areas which have been sprayed with herbicides or pesticides
      5) Using school board approved means of transportation
   c) Instruct the students in:
      1) Safe methods of personal and equipment transport over the study area
      2) Recognition and avoidance of poisonous plants and animals
      3) The use of appropriate foot gear and other clothing
      4) Safe methods of working in deep or turbulent bodies of water, including the wearing of life jackets
      5) The proper use of equipment, including the wearing of eye protective devices
   d) Provide adequate supervision

3. Emergency Procedures

   In addition to standard laboratory emergency procedures, several special precautions should be taken.

   1) A method for contacting the school office in an emergency should be specified.
   2) A local hospital or physician should be consulted for a recommended procedure for snake and spider bites.
   3) Appropriate means for transporting an injured student should be provided.

Chapter VII
Other Hazards and Control Procedures

Cryogenics

Laboratory activities in chemistry and physics that require very low temperatures are usually performed with the aid of liquid nitrogen. Liquid nitrogen is readily available and presents some very specific hazards that require special considerations. Consider the following when using liquid nitrogen.

1. Maintain liquid nitrogen in a Dewar Flask which is specifically designed for its storage.
2. Liquid nitrogen should not be stored or transported in a tightly sealed container. Increased pressure from the vaporizing liquid can result in an explosion. Thermal gloves and other protective clothing should be worn to avoid frostbite and other tissue damage when using liquid nitrogen.
3. While not poisonous, liquid nitrogen can cause asphyxiation if allowed to vaporize and accumulate in a closed area, replacing oxygen. It should therefore not be allowed to vaporize into the classroom area.
4. Protective eyewear should be worn when handling liquid nitrogen.
5. DO NOT ALLOW LIQUID NITROGEN TO CONTACT SKIN!! Severe tissue Damage can result.

Fire Classification

Fire hazards from chemical reagents are enumerated in Chapter V, Chemical Hazard Control. Fire is a pervasive hazard that is not limited to chemical reagents. Oversight, carelessness, and faulty apparatus are contributing factors to fires.

The National Fire Protection Association (NFPA) classifies fires according to the characteristics of the combustible material present. Many fires will have a mixture of combustibles and have multiple classifications. The NFPA fire classification lists the most appropriate means for extinguishing these fires.

CLASS A - Ordinary combustible materials such as wood, paper, leaf litter, and cloth that are best extinguished with water. Foam and powder fire extinguishers can also be used.

CLASS B - Oil and other flammable liquids can be extinguished with foam, powder, and carbon dioxide fire extinguishers. These combustibles cannot be extinguished with water.

CLASS C - Electrical fires caused by arcing in electrical equipment are best controlled with carbon dioxide or powder fire extinguishers.

CLASS D - Combustible metals such as magnesium and sodium can be controlled by smothering in dry sand or by using a special Class D fire extinguisher.

Fire Prevention

Controlling combustibles, oxidizers, and ignition sources can reduce the threat of fire.

1. Controlling combustibles:
   a) Limit the flammable and combustible chemicals in a work area to those actually being used.
   b) Limit laboratory work to a single class of flammables at a given time.
   c) Limit the accumulation of combustible materials, such as paper, wood shavings, and clothing, in storage areas.
   d) Limit student access to areas where combustibles cannot be controlled. (Such areas would include those where recent spillage of flammables has occurred, where combustible gas leaks are suspected, or where environmental conditions have increased the hazards of combustion, as in woods and fields that have large amounts of dry litter).
2. Controlling oxidizers:
   a) Restrict access to air (the most frequently encountered oxidizer) by closing windows and doors to prevent drafting.
   b) Keep other oxidizing agents, such as chlorates and nitrates, from coming into contact with combustible materials, such as wood, paper or flammable organic compounds.

3. Controlling sources of ignition:
    a) Open flames should not be permitted near flammable liquids, combustible gases, or easily ignited combustibles.
    b) Electrical equipment should be kept free of sources of sparks or arcing and should be explosion proof.
    c) Other sources of ignition (lenses, parabolic mirrors, spontaneous combustibles, etc.) should be separated from combustible substances.

Fire Control

Advance preparation is essential to controlling fire. Monthly fire drills and periodic fire inspections must be conducted. In addition, the following precautionary measures should be taken:

2. All aisles and exits must be clear at all times.
2. Evacuation procedures and alternate routes should be clearly posted in each classroom.
3. ABC-rated portable fire extinguishers should be installed in each laboratory in accordance with NFPA-10.
4. The extinguishers must be maintained at full charge, checked periodically, and serviced.
5. All students should be instructed in fire safety, including the STOP, DROP, and ROLL techniques for clothing fires and the use of the fire blanket.
6. All staff should be trained in the proper use of the fire extinguisher and fire blanket.

Emergency Procedures

If a fire starts:

2. Activate the fire alarm and evacuate the area
3. A teacher should shut off the gas and electrical power to the laboratory using the master control switches
4. Close all windows and doors, if possible
5. Do not use a carbon dioxide or chemical fire extinguisher to put out hair or clothing fires
6. Students with clothing fires should be pushed to the floor and rolled to extinguish the flames, or wrapped in a fire blanket

7. A very small or localized fire may be controlled by a teacher using the fire extinguisher until all persons are evacuated, but leave fighting a full-scale fire to professionals
8. Notify essential school administration and obtain medical assistance as soon as possible

Radiation

Each year, equipment previously confined to universities or research laboratories is brought into public school laboratories. Much of this equipment brings new hazards.

1. Keep exposure to ionizing radiation as low as reasonably achievable.
   a) Use radiation sources in exempt quanities only, as specified in OSHA10CRF30.
   b) Maintain the radiation sources in sealed containers, and secure sources when unattended.
   c) Permit student access to radioactive materials only under direct supervision of the instructor.
2. X-ray sources are a health hazard. Use of proper shielding on all devices using electron beams, including cathode ray tubes, x-ray tubes, and television picture tubes, can control exposure to x-rays. The use of any type of x-ray equipment on students should be expressly forbidden.
3. Ultraviolet light sources can cause detachment of the retina and severe "sunburn." Control can be accomplished by shielding students' eyes from a direct or reflected source of ultraviolet light. Skin must be shielded from intense sources of ultraviolet radiation such as may occur in arc welding.
4. Laser beams are capable of producing severe burns. Even low-powered lasers can produce eye damage. To control the radiation hazards from lasers:
   a) Instruct all persons of the hazards associated with lasers
   b) Post a sign on the entrance to the area whenever a laser is in use – "**CAUTION LASER IN USE - Do not enter without permission of the instructor"**
   c) Prohibit all activities that could contribute to undiffused direct viewing of the laser beam
   d) Direct the wearing of eye protective devices that are certified "for use with laser" whenever a laser is producing radiation outside the visible spectrum
   e) Remove all unneeded reflective surfaces such as jewelry
   f) Terminate the laser beam in a non-reflective light-absorbing surface

g) Prepare and test demonstrations without students present
h) Affix expanding lens rigidly to a laser
i) Block the beam whenever it is not in use
j) Equip the laser with a key switch in the primary circuit
k) Render the laser inoperable when not in authorized use
l. Reduce optical power to the minimum necessary for use

Model Rocketry

The construction and launching of rockets and the synthesis of fuels can be hazardous and should be discouraged for two reasons: (1) the potential for explosions and fires is high, and (2) there is the danger of being struck by a rocket or parts of the rocket during launch and free fall.

CHECK LOCAL CODES FOR POSSIBLE RESTRICTIONS ON THE USE OF MODEL ROCKETS.

If model rockets are used, hazards can be controlled by:

1. Using only commercially available devices in controlled and supervised experiments
2. Limiting power sources to compressed cold gases, cold liquids, or small pre-packaged engines
3. Insuring that rocket construction is durable enough to prevent breaking up in flight
4. Equipping the rocket with an automatic parachute or other appropriate device for retarding descent to the ground
5. Prohibiting the use of explosive or pyrotechnic materials in a rocket
6. Designating a use area for rocket experimentation and prohibiting access by unauthorized personnel during experiments (this area must be large enough to permit safe recovery of the rocket under prevailing launch conditions, and should not contain or be adjacent to high voltage power lines, major highways, multistory buildings, residential areas, etc.)
7. Constructing a sturdy explosive-resistant shield (wall, sandbags, or bunker) or maintaining sufficient distance from the launch site as necessary, to protect students during launching and recovery
8. Providing for launching by remote control
9. Insuring that proper fire extinguishing devices are readily available

In the event of injury to the student, standard emergency procedures (Chapters IV and V) should be invoked.

Co-Curricular Hazards

Home assignments, science projects, and other enrichment activities can be hazardous because there is little direct supervision by the teacher. (Science projects must comply with all safety guidelines of the governing organization.)

Control measures include:

1. Careful reviewing by the teacher of the proposed activity to assess its hazard potential
2. Making students aware of hazards and safe procedures for control
3. Requiring direct supervision by a qualified adult for activities that involve hazardous materials or equipment
4. Prohibiting homework assignments involving the use of hazardous equipment or materials. The teacher is ultimately responsible for activities students are involved with at home that are part of homework assignments.

Chapter VIII
EYE, FACE, AND RESPIRATORY PROTECTION

The vulnerability of the human eye to injury and its inability to recover as rapidly or as completely as other body tissues warrant special consideration for eye protection. The Commonwealth of Virginia has enacted a variation of a model law developed by the National Society for the Prevention of Blindness. The Act of the General Assembly of Virginia (Section 22.1-275,1996) requires the wearing of eye-protection devices at all times while participating in designated school activities. As of July 1977, similar laws have been enacted in thirty-six states. The Virginia law is as follows:

§ 22.1-275 Protective Eye Devices.
Every student and teacher in any school, college, or university participating in any of the following courses:

A. Vocational or industrial arts shops or laboratories involving experience with:
   1. Hot molten metals;
   2. Milling, sawing, turning, shaping, cutting, grinding, or stamping of any solid materials;
   3. Heat treatment, tempering, or kiln firing of any metal or other materials;
   4. Gas or electric arc welding;
   5. Repair of any vehicle;
   6. Caustic or explosive materials.

B. Chemical or combined chemical-physical laboratories involving caustic or explosive chemicals or hot liquids or solids; shall be required to wear industrial quality eye protective devices at all times while participating in such courses or laboratories.

   The governing board of authority of any public or private school or the governing body of each institution shall furnish the eye protective devices prescribed in this section free of charge or at cost to the students and teachers of the school participating in the courses set out in this section; such devices shall be furnished to all visitors to such courses.

"Industrial quality eye protective devices," as used in this section, means devices providing side protection and meeting the standards of the American Standards Association Safety Code for Head, Eye, and Respiratory Protection, §2.1-1959, promulgated by the American Standards Association, Inc. (1966, c.69.)

Eye Protective Devices

There are several styles of eye protective devices that meet the American National Standards Institute (ANSI) Standards §358.1-1990. This standard supersedes ANSI Standards §2.1-1959 specified in the protective eye device law. Any eye protective device that meets this standard and provides side shields should provide adequate protection from impact hazards. Additional protection is recommended for chemicals and radiation.

1. When working with caustic or corrosive liquids, gases, vapors, or aerosols, splash resistant chemical goggles that meet Standard §87.1-1989 are recommended. Face shields are also recommended when large amounts of these substances may be splashed.
2. Eye protective devices certified for control of specific wavelengths of hazardous radiation are recommended.
3. Contact lenses offer no protection against eye injury and cannot be substituted for safety glasses and goggles. It is best not to wear contact lenses when carrying out operations where chemical vapors are present or a chemical splash to the eyes or chemical dust is possible. Contact lenses can increase the degree of harm and can interfere with first aid and eye-flushing procedures. If an individual must wear contact lenses for medical reasons, then safety glasses with side shields or tight-fitting safety goggles must be worn over the contact lenses.

Eyewash Fountain

An eyewash fountain should be available as a backup system to eye protective devices. This device should be available for immediate flushing of the eye should a chemical splash occur.

An eyewash fountain should be available in every science laboratory where chemicals are used. If a chemical is splashed in the eyes, flush the eyes for at least fifteen minutes or until medical assistance is obtained.

Refer to Chapter X, Designing for Safety, Safety Equipment, Item 2.

Respirators

Dust masks may be used to filter dust or particulate matter encountered in the classroom. *If a respirator (dust mask) is required, the school division must comply with OSHA Respirator Standard 29 CFR Part 1910.134.*

Management Procedures

The key to effective control of eye hazards is a management system based upon carefully developed policies. Such policies should be incorporated into the overall safety plan and included in the school policy manual.

Example

1. Eye protective devices shall be furnished and worn in accordance with Section 22.1-275 of *Virginia School Laws.*
    a) The eye protective devices shall meet American National Standards Institute Standard §87.1 1968.
    b) The eye protective devices should provide protection against all eye hazards.
        1) Splash-resistant goggles shall be worn in all laboratories using corrosive or caustic liquids or vapors.
        2) Goggles certified for use with specific wavelengths of potentially hazardous radiation shall be worn in laboratories using such radiation.
2. Eye protective devices shall be worn at all times by all persons in a laboratory area.
    a) Specific areas should be designated for the wearing of eye protective devices.
    b) All persons, including the instructor and visitors, shall be issued and required to wear eye protective devices prior to entering this area.
    c) Eye protective devices shall be worn over corrective lenses.

d) Regular sanitation of goggles should be accomplished with special sterilizing cabinets or chemicals.
e) It is strongly recommended that individual goggles be issued to each student.
f) An eyewash fountain shall be readily available and operable. The device should be flushed weekly.
g) An emergency drill should be developed and implemented to familiarize all students with emergency procedures for eye injuries.
h) All students shall be thoroughly instructed in the specific hazards to be encountered in a designated activity and in safe procedures for conducting the activity.
i) The classroom shall be supervised in such a manner as to eliminate eye hazards resulting from student misconduct.

Chapter IX
DOCUMENTATION

Several forms of documentation are recommended to insure maximum instructor and student safety awareness. Such documentation should enable teachers and supervisors to assess potential hazards to determine probable cause if an accident occurs. The recommended documentation includes inventories, personal protective equipment records, equipment and maintenance records, accident reports, safety instruction records, fire extinguisher records, and safety training documentation.

Inventories

All equipment, chemicals, and supplies should be inventoried at least once a year. Such inventories allow rapid assessment of hazards, document the need for supportive materials, and identify obsolete or otherwise useless equipment and supplies. Inventories useful in the science instructional program are discussed in more detail in Chapter II, Assessing Needs.

Personal Protective Equipment Management Records

The written records that should be kept of personal protective equipment include:

1. A signed and dated parent-student safety contract acknowledging protective equipment training for each student who participates in laboratory activities
2. The name, amount, date acquired, and storage location for personal protective equipment
3. Name of student and date of issue
4. Date and condition of equipment when returned
5. Date of repair or replacement of faulty equipment
6. Date of sterilization of equipment

Laboratory Equipment Maintenance Records

All equipment should be inspected monthly and certified as being in safe operating condition. Inoperable and unsafe equipment, or equipment which breaks

during operation should be tagged defective and withdrawn from use. Equipment repair and maintenance records should include:

1. Name and serial number of equipment
2. Supplier and date acquired
3. Dates of inspection
4. Date reported inoperable and withdrawn from service
5. Description of malfunction
6. Date and copies of repair requests
7. Date repaired and returned to service

Accident Reports

An accident report should be completed and filed in the school records immediately following an accident. The report should contain the following information:

1. Name of supervising teacher
2. Name(s) of injured student(s)
3. Date and time of accident
4. Location of accident
5. Description of activity in which student was injured
6. Description of accident
7. Emergency procedures administered
8. Statements of witnesses to the accident

Exhibit I (p. 43) illustrates a suggested accident report form.

Safety Instruction Records

Written lesson plans that include safety instructions given to a specific class can be used to document instruction. Teachers and students working in the laboratory are to be instructed annually in laboratory safety and the chemical hygiene plans. Documentation of this training is to be kept on file as designated by the chemical hygiene officer.

Parent, student, and teacher agreements on student conduct and responsibilities are recommended. A code of conduct should be formulated similar to that required by the *Standards of Quality for Public Schools in Virginia*. These should serve to make parents and students aware that hazards exist in a science laboratory and field study

settings and that specific precautions are to be taken. It is suggested that both the parent and student sign a copy of the agreement. Exhibit II (p. 44) illustrates two examples of this type of agreement.

Permission of the parent for a student to engage in off-ground activities should be secured prior to undertaking this type of instruction. Permission slips should indicate the nature and location of the activity, potential hazards, method of transportation, time of departure and return, supervision to be provided, and any special precautions to be taken by the parent.

Fire Extinguisher Records

Fire extinguishers must be readily available in science laboratories and operable. A periodic program of inspection, maintenance, and repair should be implemented. Fire extinguisher records should list extinguishers by type, location, size, and date on which the extinguisher is certified to be usable. Safety training in the use of fire extinguishers should be implemented including documentation of those attending.

EXHIBIT I

SAMPLE ACCIDENT REPORT FORM

Name of Supervising Teacher:

_____

Date Filed: _____

1. Accident Occurred:

   Date: _____ Time:_____

   Location:_____

2. Name and Address of Injured:_____

   _____

3. Nature of Injury :_____

4. Description of Accident (Include brief description of activity in which injured party was engaged):_____

5. Witness (Name and association with injured - lab partner, etc.):_____

   _____

6. Emergency Procedure Taken:_____

7. Notification of Parent or Guardian (Indicate person notified) and means of notification:_____

8. Type of Medical Attention Received:
   Emergency Room: _____

   School Nurse :_____

   Private Physician (Name):_____

EXHIBIT II

SAMPLE PARENT-STUDENT SAFETY CONTRACT

Students will be removed from the science activity area by the teacher if:

a. Their personal appearance or dress is such that they can cause injury to themselves or to other students;

b. They are behaving in such a manner that they pose a potential injury to themselves or to other students;

c. They are not following the prescribed safety rules for the laboratory or the particular science activity being conducted;

d. They are going beyond the limits of the science activity into areas that may lead to an unsafe situation;

e. They have not completed the pre-experiment activities that will allow them to work safely in the laboratory situation.

I, _____ (student), have read and understand the above rules.

I, _____ (parent), have read the above rules. I have discussed them with my child and feel that my child understands them. I would like to inform the school that my child has the following physical or medical conditions which could affect his/her learning in a science class.

1.

2.

3.

Home Phone Number:_____ Business Phone Number:_____

(continued on next page)

EXHIBIT II

PARENT-STUDENT SAFETY CONTRACT (Continued)

I, _____ (teacher), have received a copy of this form from _____(student's name) on _____ (date). A copy of this agreement was given to the student and a copy put in my files.

I agree to:

1. Follow instructions explicitly;
2. Perform only authorized experiments;
3. Protect eye, face, hands, body, and long hair;
4. Practice good housekeeping;
5. Get help fast from predetermined sources;
6. Know location of first-aid and fire-fighting equipment;
7. Report at once all accidents and unusual occurrences;
8. Never "horse around";
9. Ask questions if I don't understand what to do.

I understand the need for safe attitudes and behavior in the laboratory. Safe practices are for the protection of others and myself. I agree to act within the limits of the posted rules.

Student's Signature:_____

Parent's Signature:_____

Teacher's Signature:_____

Date:_____

Chapter X
DESIGNING FOR SAFETY

Sound management and instructional practices constitute the major portion of an effective safety program. The design of the instructional space dictates to some extent the instructional program which may be carried out therein. Some activities cannot be implemented unless specific safety equipment is available. In the following suggestions for laboratory design, three assumptions have been made concerning instructional care:

1. Each laboratory is a working area designed to provide students with actual experience in scientific activities
2. Each area must be sufficiently flexible to accommodate future, as well as present instructional needs
3. Where flexibility is at variance with safety, the safety considerations must predominate

Laboratory Construction

There are many appropriate laboratory designs. The design should be for the science instruction that will be implemented in the facility. The design should also have the flexibility to accommodate several types of science programs or changes in science programs.

Specific Recommendations

1. Each laboratory unit should have two (2) exits that are not adjacent to each other. Exits into adjoining classrooms and, where usable, windows may be counted. (National Fire Protection Association-45, 1998, and Virginia Occupational Safety and Health Standards for General Industry, 1977).
2. The laboratory should be designed to accommodate only the recommended number of students.
3. The number of designated student laboratory stations installed should determine the occupant load. “Class enrollment should not exceed the designed capacity of the room” (l995 Virginia Science Standards of Learning, K-12 Safety).

4. All electrical installations should conform to the provisions of the national electrical code (NFPA-70, 1998). Electrical outlets on work surfaces where spillage of conducting fluids is expected should be considered extra-hazardous.
5. Provisions should be made to protect gas, water, and electrical outlets from vandalism by students. These services should be available only to students participating in laboratory activities. Students who are in lecture sections or who have been assigned reading or other classroom activities should have seating and work surfaces at a distance greater than arm's length from these services.
6. Work surfaces where caustic or corrosive materials are to be used should be standing height of 36 inches (92 cm).
7. Ventilation for all laboratories shall conform to NFPA-45, 1998. Laboratories without conventional windows should have a source of "make-up air."[1] Laboratory air should not be re-circulated to other parts of the building by the heating or air conditioning system.
8. Fume hoods should be installed in all laboratories where flammable or toxic vapors or airborne particles are released or generated (NFPA-45,1998). A face velocity of 100 fpm is recommended. Since hoods are routinely used for potentially explosive mixtures of flammable vapors and air, all electrical connections such as switches, lights, and motors should be explosion proof. All hood controls should be located outside the vented area. Sufficient "make-up air" must be provided for hood operation.
9. The laboratory should be designed and constructed in accordance with Americans With Disabilities Act and ANSI standard 117.1, 1998 in such a manner as to permit use by handicapped persons.
10. The layout should be such that a 54-inch (137 cm) aisle exists between workstations where students must work back-to-back. All other corridors between stations should be a minimum of 40 inches (102 cm).
11. The design should provide a minimum of 45 square feet (4.2 square meters) of space per student in a laboratory/classroom.

[1] Make-up Air – Volume of air drawn into the designated space at the same rate as air is removed from the space by positive ventilation.

Storage Space

Storage space should be provided to insure that all equipment, chemicals, and other teaching supplies can be secured against unauthorized use. In-room storage should be installed in such a manner as not to hamper student movement to workstations or exits (NFPA 45, 1998).

Special Storage Considerations

Chemical storage in a school building should serve four functions:

1. Provide security against unauthorized use
2. Restrict or vent emissions from stored chemicals
3. Protect the chemicals from fire
4. Prevent unintended chemical reactions

Special Recommendations

1. All storage areas that contain poisonous, corrosive, caustic, or explosive materialsmust be provided with a secure lock system. This would include all chemicals rated NFPA 2, 3, or 4 on either health, reactivity, or flammability.
2. Flammable storage cabinets should be constructed in accordance with the requirements of NFPA 30, 1998 edition. Such cabinets should be vented to the outside of the school building.
3. High school laboratory suites should have a storage room constructed and ventilated in accordance with NFPA 30, 1998 edition. The floors in such storage rooms should be constructed of chemical resistant material and form a liquid-tight catch basin. The storeroom should be equipped with an exhaust system capable of six changes of room air per hour. All electrical connections such as lights, switches, and motors should be explosion proof. All circuits should include Ground Fault Interrupters.
4. Each laboratory area should have an adjacent preparation area with a minimum of 10 square feet per student based on the design capacity of the adjoining laboratory areas.

Safety Equipment

Safety equipment should be provided to reduce the potential for accidental injury. The provision of such equipment should depend on the probability of an accident occurring. The risk of having a person splashed with a concentrated acid is very high in a chemistry lab and low in a physics lab under normal operating conditions.

1. Portable fire extinguishers (ABC rated) should be located, installed, and maintained in accordance with the *Standards for the Installation of Portable Fire Extinguishers*, NFPA 10, 1998, and PAR 1910:157 Sub Part L of the *Virginia Occupational Safety and Health Standards for General Industry,* 1977.
2. Eyewash fountains are recommended for all laboratories. These should be capable of providing a steady low-pressure (25 psi) flow of water for a minimum of 15 minutes.
3. Secure master controls should be provided for gas, water, and electricity. In the event of fire, electrical shock, flooding, or explosion, the teacher should be able to shut down the services and initiate emergency procedures.
4. Safety shower(s) should be provided where strong caustics, corrosives, or skin-absorbable poisons are utilized in the program. Most chemistry programs would be in this category. ANSI standard 117.1 recommends the following specifications for safety showers:
   a) Showers should be located no further than 50 feet (15 m) from work-stations where corrosives and caustics are being used and preferably no more than 25 feet (7.6 m) from point of egress
   b) Showers should be located away from electrical apparatus, power outlets, or panels
   c) Shower locations should be indicated by a painted circle or square on the floor
   d) Shower heads should be located 7 to 8 feet (2 to 2.5 m) above the floor and a minimum of 25 inches from the nearest wall
   e) A floor drain for the showers is strongly recommended
   f) The shower valve should be operated by a ring and chain, triangle, and rod or chain arrangement
   g) The shower should be capable of delivering a flow-rate of 60 gallons per minute (200 l) at a pressure of 20 to 50 psi
   h) Showers should be tested semi-annually

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APPENDIX

Portions of various regulations, policies, or laws are included in this appendix. In most cases, documents are too long to be included completely. To obtain the most complete and current information check the appropriate Web site which is listed in the "Points of Contact" section of this appendix.

CHEMICAL HAZARDS

This list is not inclusive of all potential chemical hazards but is intended to acquaint teachers and administrators with a sample of known chemical hazards. School personnel are expected to protect students from these hazards through proper handling, usage, and storing of these chemicals. If appropriate facilities and equipment do not exist to safely use such chemicals, it is recommended that said chemicals be removed from the school. It is also strongly advised that all positive carcinogens be removed.

SINCE CHEMICALS ARE CONSTANTLY BEING TESTED FOR HEALTH EFFECTS, PLEASE REFER TO THE MATERIAL SAFETY DATA SHEETS AVAILABLE FOR ALL CHEMICALS FOR CURRENT HEALTH HAZARD INFORMATION.

Explanation of Toxicity:

LCLo - lowest published lethal concentration. This is the lowest known concentration to kill. It will usually be given in parts per million (ppm) or in milligrams (mg) or micrograms (ug) per cubic meter (m^3) of air.

LDLo - lowest published lethal dose is the smallest dose known to cause death. It is given in grams (g), milligrams (mg) or micrograms (ug) per kilogram (kg) of body weight.

LD_{50} - Lethal dose for 50% of the treated population.

GROUP A - SELECT CARCINOGENS

Anthracene: carcinogen of skin

Asbestos: positive human carcinogen

Ascarite: positive human carcinogen

Acetamide: positive animal carcinogen

Acrylonitrile: possible carcinogen; toxic by inhalation and skin absorption; severe skin and eye irritants; FLAMMABLE

Ammonium Chromate: possible carcinogen; positive teratogen in mice; POISON; oral human lethal dose (LDLo) 5 mg/kg

Arsenic Trioxide: suspected human carcinogen; POISON either by dust inhalation or ingestion LD_{50}1430 ug/kg

Benzene: suspected human carcinogen; possible teratogen; TOXIC to central nervous system LDLo 130 mg/kg

Benzone: possible carcinogen and teratogen

Cadmium: possible animal carcinogen – POISON; inhalation of dusts or fumes LCLo 88 ug/m^3 soluble compounds highly toxic by ingestion

Cadmium Chloride: positive animal carcinogen

Cadmium Sulfate: positive animal carcinogen and teratogen; POISON; inhalation human LCLo 20 ppm; oral human 43 mg/kg; toxic to central nervous system, known to cause liver and kidney damage in humans

Chloroform: suspected animal carcinogen and teratogen; POISON; oral LDLo 140 mg/kg, inhalation LCLo 10ppm; affects heart muscle, liver, and kidneys

Chromium: suspected carcinogen; hexavalent compounds can cause skin ulcers and dermatitoxic by inhalation LCLo 4500 ug/m^3 OSHA std air-TWA 1 mg/m^3

Chromium III Oxide: suspected animal carcinogen

Chromium IV Oxide: (chromium trioxide) suspected carcinogen, mutagen, teratogen

Cobalt: suspected carcinogen

Colchicine: possible animal carcinogen, mutagen, teratogen, POISON; 0.02 gm may be fatal if ingested

1.2 Dichloroethane: possible carcinogen; POISON; inhalation LCLo 4000 ppm/hour; oral LDLo 428 mg/kg

p-Dioxane: possible animal carcinogen; POISON; affects liver and kidneys; inhalation LCLo 470 ppm, oral 500 mg/kg; may form EXPLOSIVE peroxides

Diphenyl Ester Carbonic Acid: suspected animal carcinogen

Lead Arsenate: (arsenic acid, lead (2+) sale): positive animal carcinogen; POISON; oral LDLo 10mg/kg

Lead Chromate VI: possible carcinogen; toxic by inhalation and ingestion

Methyl Iodide: positive animal carcinogen; TOXIC oral LDLo 50 mg/kg; skin absorption 1 gm/10 meter

Nickel: positive animal carcinogen; allergen; FLAMMABLE

Nickel II Acetate: animal carcinogen

Nickel Carbonate: suspected carcinogen

Nickel II Oxide: suspected animal carcinogen

Phenol: suspected carcinogen; POISON; oral LDLo 140 mg/kg; strong tissue irritant readily absorbed through skin

Potassium Chromate: suspected animal carcinogen

Salenium: suspected carcinogen; POISON; toxicity similar to arsenic (toxicity for arsenic not given)

Sodium Arsenate: suspected animal carcinogen and teratogen; POISON; oral LDLo 5 mg/kg

Sodium Arsenite: suspected human carcinogen; POISON, oral LDLo 5 mg/kg

Sodium Nitrite: potential carcinogen; TOXIC LDLo 50 mg/kg; Oxidize-forms EXPLOSIVE mixture with organic compounds

Stearic Acid: potential carcinogen (skin)

Sudan IV: positive animal carcinogen

Tannic Acid: positive animal carcinogen

Thioacetamide: positive animal carcinogen

Thiourea: positive animal carcinogen

O-Toluidine: suspected human carcinogen; dermal absorption

Trichloroethylene: suspected animal carcinogen; TOXIC to central nervous system, inhalation LCLo 160 ppm

Uranium: suspected carcinogen; RADIOACTIVE; FIRE HAZARD; ignites spontaneously in air

Uranyl Acetate: suspected carcinogen

Uranyl Nitrate: suspected carcinogen; EXPLOSIVE; severe fire and explosion risk in contact with organic compounds; TOXIC

Urethane: suspected carcinogen and mutagen

Vinylite: possible carcinogen

GROUP B - HIGHLY TOXIC (POISONS)

Aluminum Chloride: (anhydrous) strong skin irritant; reacts violently with water to give HCL

Ammonium Bichromate: allergen (inhalation of dust can cause asthmatic symptoms; skin and eye irritant; OXIDIZER; fire hazard; forms EXPLOSIVE mixtures with organic compounds)

Ammonium Vanadate: TOXIC; oral LDLo 18 mg/kg

Aniline: TOXIC; affects central nervous system; oral LDLo 50 mg/kg; allergen; may cause contact dermatitis

Aniline Hydrochloride: same toxicity as aniline

Antimony: TOXIC; inhalation LCLo 4700 ug/m^3; antimony compounds irritant to skin and mucous membranes

Antimony Chloride: TOXIC and CORROSIVE, strong irritant to eyes and skin; LDLo 73 mg/kg inhalation

Antimony Oxide: TOXIC; LDLo 2 mg/kg; may cause dermatitis

Antimony Potassium Tartrate: TOXIC, oral LDLo 2 mg/kg

Arsenic Chloride: poisonous as arsenic; strong irritant to eyes and skin (toxicity of arsenic is NOT indicated)

Arsenic Pentoxide: POISON; LDLo 5 mg/kg

Barium Compounds: All barium compounds are TOXIC by ingestion and are also skin irritants

Barium Chloride: oral LDLo 11.4 mg/kg

Benzoyl Peroxide: TOXIC-pulmonary system; LDLo 500 mg/kg. FLAMMABLE; EXPLOSIVE; may explode spontaneously when dry

Beryllium Carbonate: highly TOXIC by inhalation and ingestion

Bromine: severe skin irritant; CORROSIVE; TOXIC; oral LDLo 14 mg/kg; inhalation LDLo; 100 ppm; OXIDIZER; forms EXPLOSIVE mixtures with organic compounds

Butanol: TOXIC; irritant to skin and eyes; LCLo 25 ppm

Cadmium Compounds: highly TOXIC by inhalation of dust or fumes; soluble compound highly TOXIC by ingestion

Calcium Cyanide: highly TOXIC; decomposes in moist air, water, and weak acids to form hydrogen cyanide; LDLo 5 mg/kg

Catechol (pyrocatechol): TOXIC LDLo 55 mg/kg; allergen; threshold limit value - air 1 ppm

Chloral Hydrate: TOXIC; affects central nervous system LDLo 4 mg/kg; liquid and vapor dangerous to eyes

Chlorobutanol (chloretone): TOXIC; LDLo 50 mg/kg; affects central nervous system

Chloretone (chlorobutanol): TOXIC; LDLo 50 mg/kg; affects central nervous system

Chlorpromazine: TOXIC; affects central nervous system; LDLo 50 mg/kg

Chromic Acid: corrosive to skin; FIRE HAZARD: OXIDIZER, forms explosive mixtures with organic compounds

n,n-Dimethylaniline: TOXIC; depressant of central nervous system; absorbed through skin; LDLo 50 mg/kg; maximum tolerance to air 5 ppm

2,4-Dinitrophenol: highly TOXIC; absorbed by skin; may cause dermatitis and liver damage; dust inhalation can be fatal; LDLo 36 mg/kg. EXPLOSIVE

Ethylene Oxide: TOXIC; cause hypersensitivity and skin irritation, Mutagenic; inhalation LCLo 30 mg/m^3; FIRE HAZARD

Ether: strong narcotic; FLAMMABLE; EXPLOSIVE due to peroxide formation

Formaldehyde: (gas) highly TOXIC; strong irritant LCLo 13.8 ppm; in solution; TOXIC through breathing vapor and skin contact

Hexachlorophene: TOXIC to central nervous system LDLo 50 mg/kg

Hydrobromic Acid: TOXIC; CORROSIVE; irritant; LCLo 3 ppm; reacts with water to produce toxic and corrosive fumes

Hydrofluoric acid: TOXIC; irritant; CORROSIVE LCLo 50 ppm

Hydrogen sulfide: strong irritant and asphyxiant LCLo 660 ppm; FLAMMABLE

Hydroquinone: irritant; allergen; LDLo 29 mg/kg

Iodine Crystals: highly TOXIC by ingestion and inhalation; strong irritant to eyes and skin; LDLo 2000 mg/kg

Lead Compounds: highly TOXIC by ingestion and inhalation

Magnesium Chlorate: TOXIC; LDLo 50 mg/kg; OXIDIZER; forms flammable and explosive mixture with organic compounds

Mercury: TOXIC by ingestion, inhalation and skin absorption; applies to all mercury compounds

Mexitylene: TOXIC; LDLo 50 mg/kg

Nicotine: POISON; LDLo 1 mg/kg; can be absorbed by skin

Oxmium Tetroxide: TOXIC; strong eye and mucous membrane irritant; LCLo 0.1 mg/m^3

Paris Green: (bis(aceto) hexametaarsenitotetra copper); POISON; LDLo 5 mg/kg

1-Phenyl-2-Thiourea: TOXIC; rat LD_{50} 3 mg/kg

Phthalic Anhydride: skin irritant

Potassium Oxalate: TOXIC by inhalation and ingestion; CORROSIVE

Phyrogallic Acid: TOXIC by ingestion and skin absorption; LDLo 50 mg/kg

Phenyl Salicylate (salol): TOXIC; LDLo 50 mg/kg

Silver Cyanide: highly TOXIC by ingestion and inhalation

Silver Nitrate: highly TOXIC and strong irritant to skin and tissue

Sodium Azide: TOXIC; LDLo 5 mg/kg; EXPLOSIVE

Sodium Fluoride: TOXIC to central nervous system; LDLo 75 mg/kg

Sodium Permanganate: TOXIC; LDLo 2400 ug/kg; OXIDIZER; forms FLAMMABLE and EXPLOSIVE mixtures with organic compounds

Sodium Silicofluoride: strong tissue irritant; LDLo 2400 ug/kg

Sodium Sulfide: TOXIC; strong tissue and skin irritant; LDLo 50 mg/kg; FIRE HAZARD

Sodium Thiocyanate: TOXIC; LDLo 50 mg/kg

Stannic Chloride: CORROSIVE; yields hydrochloric acid on heating

Sulfuric Acid (fuming): highly TOXIC, strong irritant to tissue; reacts violently with water

Tetrabromoethane: TOXIC; irritant by inhalation

Toluene: TOXIC to central nervous system; LCLo 100 ppm; FLAMMABLE; forms EXPLOSIVE mixture with air

GROUP C - EXPLOSIVES AND FLAMMABLES

These chemical reagents require special precautions in handling usage and storage:

Ammonium Dichromate: OXIDIZER; forms explosive mixtures with organic materials; TOXIC (see Group B)

Aniline: moderate FIRE HAZARD; TOXIC (see Group B)

Benzoyl Peroxide: FLAMMABLE; EXPLOSIVE: may explode SPONTANEOUSLY when dry; TOXIC (see Group B)

Bromine: OXIDIZER; FIRE HAZARD or EXPLOSIVE when in contact with organic compounds; TOXIC (See Group B)

Chromic Acid: OXIDIZER; FIRE HAZARD; forms EXPLOSIVE mixture in contact with organic materials

Cyclohexane: FIRE HAZARD

2,4-Dinitrophenol: EXPLOSIVE; severity increases with drying; TOXIC (see Group B)

Ethylene Oxide: FIRE HAZARD; TOXIC (see Group B)

Ether: FLAMMABLE; forms EXPLOSIVE mixture with air, EXPLOSIVE due to formation of peroxides with aging; TOXIC (see Group B)

Gasoline: FLAMMABLE; forms EXPLOSIVE mixture with air

Gunpowder: EXPLOSIVE

Hydrogen Sulfide: FLAMMABLE gas; TOXIC (see Group B)

Lithium: FIRE HAZARD; severe EXPLOSION risk (reactivity) with water, nitrogen, acids or oxidizers

Magnesium: FIRE HAZARD

Magnesium Chlorate: OXIDIZER; dangerous fire risk in contact with organic materials; TOXIC (see Group B)

Mercuric Nitrate: OXIDIZER; forms FLAMMABLE and EXPLOSIVE mixtures with organic materials; TOXIC (see Group B)

Methyl Ethyl Ketone: FLAMMABLE; forms EXPLOSIVE mixture with air; TOXIC (see Group B)

Methyl Methacrylate: FLAMMABLE; forms EXPLOSIVE mixture with air; TOXIC (see Group B)

Pentane: FLAMMABLE; forms EXPLOSIVE mixture with air; TOXIC

Perchloric Acid: OXIDIZER; severe EXPLOSION hazard in contact with organic materials; VERY DANGEROUS

Petroleum Ether: FLAMMABLE; forms EXPLOSIVE mixture with air; TOXIC (see Group B)

Phosphorus (red): FLAMMABLE; moderate EXPLOSIVE; reacts with oxygen and water to generate phosphine (which is highly TOXIC by inhalation); (white): FLAMMABLE and POISON; LDLo 1400 ug/kg; ignites spontaneously; must be stored under water

Phosphorus Pentoxide: FIRE HAZARD; reacts violently with water

Picric Acid: EXPLOSIVE; more powerful than closely related TNT, TOXIC (see Group B)

Potassium: FIRE HAZARD: can ignite spontaneously with air; violent reaction with water; OXIDIZER; forms EXPLOSIVE peroxides while aging and can explode when handled or cut; must be stored under liquid hydrocarbons

Potassium Chlorate: OXIDIZER; forms EXPLOSIVE mixture with organic compounds; TOXIC

Potassium Periodate: OXIDIZER; FIRE HAZARD in contact with organic materials

Potassium Permanganate: OXIDIZER; forms FLAMMABLE and EXPLOSIVE mixtures with organic compounds; ignites spontaneously on contact with glycerine or ethylene glycol; TOXIC

Potassium Sulfide: FIRE HAZARD; which may ignite spontaneously; EXPLOSIVE as dust or powder; POISON; LDLo 50 mg/kg

Pyridine: FLAMMABLE; forms EXPLOSIVE mixture with air; TOXIC; LDLo 500 mg/kg

Silver Oxide: OXIDIZER; forms FLAMMABLE and EXPLOSIVE mixtures with organic materials or ammonia; moderately TOXIC

Sodium: FLAMMABLE solid; violent reaction with water; severe caustic irritant to tissue; must be stored under liquid hydrocarbons

Sodium Azide: EXPLOSIVE (HEAT SENSITIVE) POISON

Sodium Chlorate: OXIDIZER; forms FLAMMABLE EXPLOSIVE mixtures with organic compounds

Sodium Permanganage: OXIDIZER; forms FLAMMABLE EXPLOSIVE mixture with organic compounds; TOXIC (see Group B)

Sodium Sulfide: Unstable compound; FIRE HAZARD; TOXIC (see Group B)

Strontium: SPONTANEOUSLY FLAMMABLE with air; store under naphtha

Strontium Nitrate: OXIDIZER; forms FLAMMABLE EXPLOSIVE mixture with organic compounds

Thermite and related compounds (mixture of iron oxide and powdered aluminum): FIRE HAZARD; once used for incendiary bombs

Titanium Trichloride: OXIDIZER: forms FLAMMABLE mixture with organic materials; TOXIC

Toluene: FLAMMABLE; forms EXPLOSIVE mixture with air; TOXIC (see Group B)

2,2,4-Trimenthylpentane: FLAMMABLE; forms EXPLOSIVE mixture with air; moderately TOXIC by inhalation and ingestion

LABORATORY SAFETY CHECKLIST
(Sample)

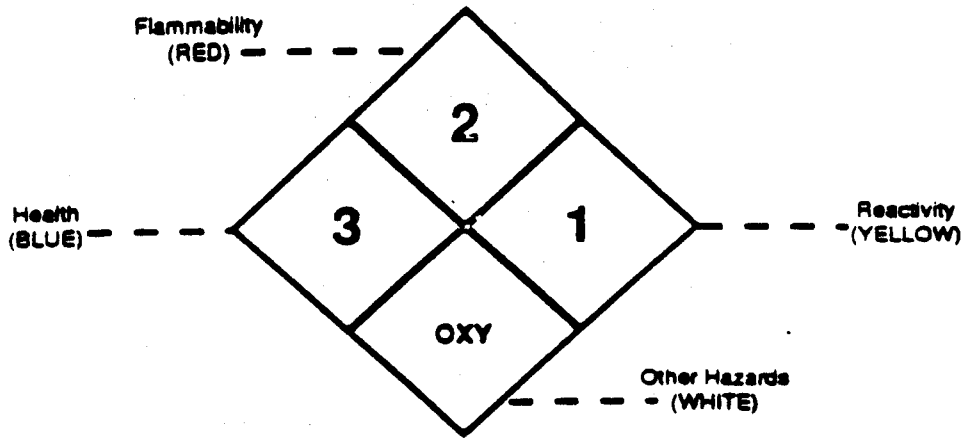
		Acceptable	Not Acceptable
	General Environment		
1.	Aisle space adequate for movement and exit.		
2.	Emergency exits adequate, identified, and accessible.		
3.	Hazardous operations isolated or protected.		
4.	Hazardous operations between working area and exit.		
5.	Sinks and pegboards not used for permanent storage.		
6.	Frequency of testing eyewash fountains and safety showers.		
7.	Sufficient eyewash fountains and safety showers easily accessible, identified, and working properly.		
8.	Controls for major services accessible.		
9.	Adequate fire and safety equipment available and readily accessible.		
	Hoods		
1.	Adequate air flow for material being processed.		
2.	Uncluttered, uncrowded, clean storage.		
3.	Services controlled from outside of hood.		
4.	Fan and indicator light operating.		
5.	Hood used only for proper purpose not as storage.		
6.	Sash operates properly, condition of counterweight cables, marked for opening of minimum air, velocity, etc.		
	Services		
1.	Piping and electrical services labeled and identified.		
2.	Switches and circuits properly labeled.		
	Electrical		
1.	Wiring in good condition (not worn, frayed, abraded, or corroded).		
2.	Proper grounding – 3 wire system used on all equipment.		
3.	No temporary setups, overloaded circuits, bread-board wiring.		
4.	Indicator light for each piece of equipment operative.		
5.	Possible shock hazards from pipes, wet areas avoided.		
6.	No temporary lighting or power connections.		
	Chemical Reagents and Stocks		
1.	Properly located, within easy reach, heavy containers at bottom.		
2.	Trays under reagent bottles.		
3.	Reagents properly and clearly labeled.		

4.	Minimum quantities on hand.		
5.	No incompatible storage or inherently dangerous chemicals present.		
6.	Separators used to prevent breakage.		
7.	Flammables stored in safety cans and safety cabinets.		
8.	Storage away from light, heat, oxidizers, etc.		
9.	Chemicals requiring periodic venting labeled and vented frequently.		
10.	Frequent inspection for leakage or deterioration (such as sediments, discolorations, etc.).		
11.	Chemicals properly segregated on storage shelves.		
12.	MSDS readily available.		
	Miscellaneous Practices		
1.	Pipette fillers used where indicated.		
2.	Guards on desiccators.		
3.	Safety pouring spouts for bottles.		
4.	Electrical mantles for heating, distillations.		
5.	All mercury sources contained.		
6.	No unattended reactions.		
7.	Safety shields available and used.		
	Disposal Practices		
1.	Separate containers for waste glass, chemicals, solids, etc.		
2.	Proper disposal of solvents (no dumping into sinks).		
3.	Approved procedures for disposal of chemicals.		
4.	Approved procedures for disposal of toxic and explosive chemicals.		
5.	Samples properly labeled and disposed of regularly.		
6.	Condition of drain system properly maintained.		
7.	Drain systems trapped properly.		
8.	Approved procedure for disposal of organisms and microorganisms.		
	Safety Equipment		
1.	Face shields and goggles available and inspected regularly.		
2.	Fire blankets available and inspected regularly.		
3.	Protective clothing such as aprons, gloves and/or mittens available.		
4.	Standard procedures for use of protective clothing published and enforced.		
5.	Proper type fire extinguishers available, readily accessible, and inspected regularly.		
	General Procedures		
1.	Employees informed of procedure to be followed in case		

	of power outage.		
2.	Emergency procedures established in case of fire, breakage, or runaway reaction.		
3.	Evacuation procedure established and drills held regularly.		
4.	All personnel informed as to dangers and proper emergency procedures.		
5.	Proper danger/caution signs posted, updated regularly.		
6.	Safety signs posted and legible.		
7.	Chemicals and solutions issued from a central source.		
8.	Chemicals issued have appropriate hazard labels.		
9.	Employees trained in first-aid procedures.		
10.	Emergency first-aid chart posted.		
11.	Food and beverage permitted in designated areas only.		
12.	All personnel have a general understanding of toxic, corrosive, and explosion hazards.		
13.	Chemical usage controlled and an accurate inventory maintained.		
14.	MSDS location posted.		
	Equipment		
1.	Flammables stored in an explosion-proof refrigerator or flammables cabinet.		
2.	Designated separate refrigerator for food or beverage storage.		
3.	Explosion-proof equipment used where necessary.		
4.	Temperature-limiting devices, fuses, relief valves, properly located, installed, and inspected.		
5.	Compressed gas cylinders properly labeled and secured in an upright position.		
	a. Empty cylinders so marked and removed properly.		
	b. Tubing and valves adequate and valve protection caps in place when not in use regardless of whether cylinders are empty or full.		
	c. Safe operating procedures posted.		
	d. All compressed gas cylinders meet current ICC and CGA regulations.		
6.	No chipped and/or scratched glassware or glass utensils being used.		
7.	Bottles properly filled to allow for expansion.		
8.	Laboratory hand tools in good condition.		
9.	Handling equipment such as bottle carriers, carboy tilter, clamps, supports, etc., adequate and in proper condition.		
10.	Pressure vessels inspected by approved sources and comply with proper codes.		
11.	Personnel barricades used when pressure vessels in		

	operation.		
12.	Tubing and connections in usable condition and properly used.		

Adapted from Anaheim Union High School District “Laboratory Safety Checklist”
Anaheim, California



Identification of Health Hazard Color Code: BLUE		Identification of Flammability Color Code: RED		Identification of Reactivity Color Code: YELLOW	
	Type of Possible Injury		Susceptibility of Materials to Burning		Susceptibility to Release of Energy
Signal		Signal		Signal	
4	Materials which on very short exposure could cause death or major residual injury even though prompt medical treatment is given.	4	Materials which will rapidly or completely vaporize at atmospheric pressure and normal ambient temperature, or which are readily dispersed in air and which will burn readily.	4	Materials which in themselves are readily capable of detonation or of explosive decomposition or reaction at normal temperatures and pressures.
3	Materials which on short exposure could cause serious temporary or residual injury even though prompt medical treatment is given.	3	Liquids and solids that can be ignited under almost all ambient temperature conditions.	3	Materials which in themselves are capable of detonation or explosive reaction, but require a strong initiating source, or which must be heated under confinement before initiation, or which react explosively with water.
2	Materials which on intense or continued exposure could cause temporary incapacitation or possible residual injury unless prompt medical treatment is given.	2	Materials that must be moderately heated or exposed to relatively high ambient temperatures before ignition can occur.	2	Materials which in themselves are normally unstable and readily undergo violent chemical change but do not detonate. Also materials which may react violently with water or which may form potentially explosive mixtures with water.
1	Materials which on exposure could cause irritation but only minor residual injury even if no treatment is given.	1	Materials that must be preheated before ignition can occur.	1	Materials which in themselves are normally stable, but which can become unstable at elevated temperatures and pressures, or which may react with water with some release of energy, but not violently.
0	Materials which on exposure under fire conditions would offer no hazard beyond that of ordinary combustible material.	0	Materials that will not burn.	0	Materials which in themselves are normally stable, even under fire exposure conditions, and which are not reactive with water.

Other Hazards - Color Code: WHITE
Oxy - Oxidizer, ACID - Acid, ALK - Alkaline, COR - Corrosive
~~W~~ - Use no water

National Fire Protection Association Symbols.

OSHA Regulations (Standards - 29 CFR)

Flammable and combustible liquids. - 1910.106

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

Standard Number: 1910.106
Standard Title: Flammable and combustible liquids.
SubPart Number: H
SubPart Title: Hazardous Materials

(d)(4)(iv)
"Ventilation." Every inside storage room shall be provided with either a gravity or a mechanical exhaust ventilation system. Such system shall be designed to provide for a complete change of air within the room at least six times per hour. If a mechanical exhaust system is used, it shall be controlled by a switch located outside of the door. The ventilating equipment and any lighting fixtures shall be operated by the same switch. A pilot light shall be installed adjacent to the switch if Class I flammable liquids are dispensed within the room. Where gravity ventilation is provided, the fresh air intake, as well as the exhaust outlet from the room, shall be on the exterior of the building in which the room is located.

..1910.106(d)(4)(v)

(d)(4)(v)
"Storage in inside storage rooms." In every inside storage room there shall be maintained one clear aisle at least 3 feet wide. Containers over 30 gallons capacity shall not be stacked one upon the other. Dispensing shall be by approved pump or self-closing faucet only.

(d)(5)
"Storage inside building" -

(d)(5)(i)
"Egress." Flammable or combustible liquids, including stock for sale, shall not be stored so as to limit use of exits, stairways, or areas normally used for the safe egress of people.

(d)(5)(ii)
"Containers." The storage of flammable or combustible liquids in containers or portable tanks shall comply with subdivisions (iii) through (v) of this subparagraph.

(d)(5)(iii)
"Office occupancies." Storage shall be prohibited except that which is required for maintenance and operation of building and operation of equipment. Such storage shall be kept in closed metal containers stored in a storage cabinet or in safety cans or in an inside storage room not having a door that opens into that portion of the building used by the public.

(d)(5)(iv)
"Mercantile occupancies and other retail stores."

(d)(5)(iv)(a)-(d)
[Reserved]

(d)(5)(iv)(e)
Leaking containers shall be removed to a storage room or taken to a safe location outside the building and the contents transferred to an undamaged container.

..1910.106(d)(5)(v)

(d)(5)(v)
"General purpose public warehouses." Storage shall be in accordance with Table H-14 or H-15 and in buildings or in portions of such buildings cut off by standard firewalls. Material creating no fire exposure hazard to the flammable or combustible liquids may be stored in the same area.

OSHA Regulations (Standards - 29 CFR)

Occupational exposure to hazardous chemicals in laboratories. - 1910.1450

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

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

(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:

(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.

"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)

(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:

..1910.1450(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.

(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]

POINTS OF CONTACT

COMMONWEALTH OF VIRGINIA AGENCIES

Virginia Department of Education
Science Specialists
P. O. Box 2120
Richmond, VA 23218
www.pen.k12.va.us
804-371-0778

Virginia Department of Labor and Industry
Division of Occupational Health
P. O. Box 12064
Richmond, VA 23219
804-371-2327

Commonwealth of Virginia
Department of General Services
Division of Consolidated Laboratory Services
1 North 14th Street
Richmond, VA. 23219
804-786-0153

Department of Environmental Quality
Hazardous Waste
101 North Fourteenth Street
Richmond, VA 23219
804-698-4147

Department of Environmental Quality (Air)
202 North Ninth Street
Richmond, VA 23240
804-698-4140

Department of Environmental Quality (Water)
4900 Cox Road
Glen Allen, VA 23060
804- 698-4109

Virginia Game and Inland Fisheries (Permits)
4010 W. Broad Street
P. O. Box 11104
Richmond, VA 23230
804-367-1000

FEDERAL GOVERNMENT OFFICES

Centers for Disease Control http://www.cdc.gov

Department of Labor and Industry
Occupational Health and Safety Administration
Regional Administrator (Region III)
Gateway Building, Suite 2100
3535 Market Street
Philadelphia, PA 19104
215-596-1201

Eisenhower National Clearinghouse for Mathematics and Science Education
http://www.enc.org

Environmental Protection Agency
Region III
841 Chestnut Building
Philadelphia, PA 19107
215-597-9800
http://www.cdc.gov

Occupational Safety and Health Administration (OSHA)
U.S. Department of Labor
http://www.osha.gov
202-693-1999

OTHER

American Chemical Society http://www.acs.org

American Conference of Governmental Industrial Hygienists
6500 Glenway Avenue, Bldg. D-7
Cincinnati, OH 45211
513-742-2020

American National Standards Institute (ANSI)
1819 L. Street N.W.
Washington, DC 20036

Council of State Science Supervisors http://csss.enc.org

Flinn Scientific http://www.flinnsci.com/

Laboratory Safety Institute http://www.labsafety.org

MSDS On-line http://www.msdsonline.com

National Association of Biology Teachers http://www.nabt.org

National Fire Protection Association
1 Batterymarch Park
P. O. Box 9101
Quincy, MA 02269-9101
http://www.nfpa.org

National Institute for Occupational Safety and Health
4676 Columbia Parkway
Cincinnati, OH 45226
1-800-356-4674

National Institute of Environmental Health Science
111 T.W. Alexander Drive
Research Triangle Park, NC 27709
919-541-0530

National Safety Council
1121 Spring Lake Drive
Itasca, IL 60143-3201
630- 285-1121

Poison Control Center 1-800-522-6337

U. S. Fish and Wildlife Services
P. O. Box 779
Hadley, MA 01035
413-253-8641

Virginia Science Standards of Learning K-12 Safety (1995)

K-12 Safety

In implementing the Science Standards of Learning, students must know how to follow safety guidelines, demonstrate appropriate laboratory safety techniques, and use equipment safely while working individually and in groups.

Safety must be given the highest priority in implementing the K-12 instructional program for science. Correct and safe techniques, as well as wise selection of experiments, resources, materials, and field experiences appropriate to age levels, must be carefully considered with regard to the safety precautions for every instructional activity. Safe science classrooms require thorough planning, careful management, and constant monitoring of student activities. Class enrollment should not exceed the designed capacity of the room.

Teachers must be knowledgeable of the properties, use, and proper disposal of all chemicals that may be judged as hazardous prior to their use in an instructional activity. Such information is referenced through the MSDS forms (Materials Safety Data Sheets). The identified precautions involving the use of goggles, gloves, aprons, and fume hoods must be followed as prescribed.

While no comprehensive list exists to cover all situations, the following should be reviewed to avoid potential safety problems. Appropriate safety procedures should be used in the following situations:

3) Observing wildlife; handling living and preserved organisms; and contact with natural hazards such as poison ivy, ticks, mushrooms, insects, spiders, and snakes

d) Field activities in, near, or over bodies of water

1) Handling of glass tubing, sharp objects, glassware, and labware

4) Natural gas burners, Bunsen burners, and other sources of flame/heat

5) Hazards associated with direct sunlight (sunburn and eye damage)

6. Use of extreme temperatures and cryogenic materials

1. Hazardous chemicals including toxins, carcinogens, flammable and explosive materials

4) Acid/base neutralization reactions/dilutions

1. Production of toxic gases or situations where high pressures are generated

i) Biological cultures, their appropriate disposal, and recombinant DNA

f) Power equipment/motors

j) High voltage/exposed wiring

11) Laser beam, UV, and other radiation.

The use of human body fluids or tissues is generally prohibited for classroom lab activities. Further guidance from the following sources may be taken into account:

e) OSHA (Occupational Safety and Health Administration)

k) ISEF (International Science and Engineering Fair Rules)

e) Public health departments and local school division protocols.