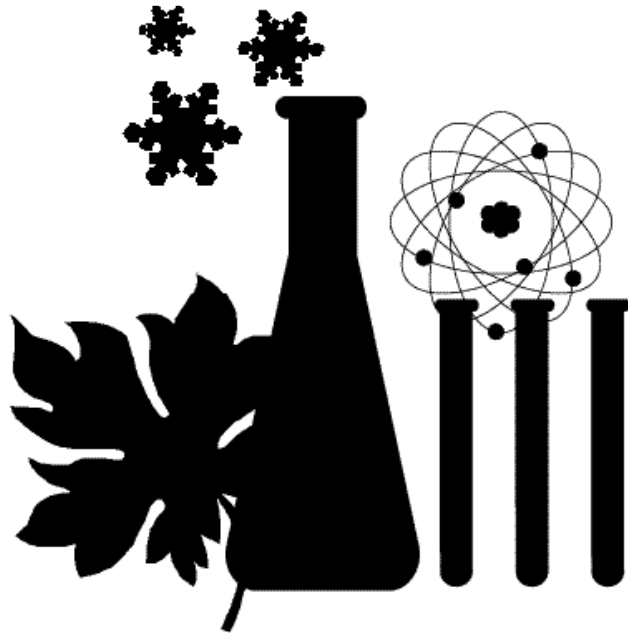


Safety in Science Teaching



Commonwealth of Virginia

Department of Education

Richmond, Virginia

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Superintendent of Public Instruction
Dr. Lisa Coons

Science Coordinator
Dr. Anne M. Petersen

NOTICE TO THE READER

Safety in Science Teaching can be found on the Virginia Department of Education's Web site at [Virginia Department of Education](#).

All safety regulations in this manual are mandated by the Occupational Safety and Health Administration (OSHA). OSHA is a federal regulatory agency authorized to inspect and examine the safety of workplaces, including public schools, and is part of the United States Department of Labor. For a comprehensive list of compliance requirements of OSHA standards or regulations, refer to Title 29 of the Code of Federal Regulations.

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 nothing will be done 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. Extra-curricular 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.

The Chemical Hygiene Plan

Hazardous chemicals present physical and/or health threats to workers in clinical, industrial, and academic laboratories. In the school setting, chemical use occurs daily throughout a school division with facilities management, food services, and in the classroom environment to include those in Career and Technical Education (CTE) and science. The chemical hygiene plan should be created in collaboration with personnel from these different areas within the school division.

The Occupational Safety and Health Administration (OSHA) Occupational Exposure to Hazardous Chemicals in the Laboratory (29 CFR 1910.1450) requires all employers with hazardous chemicals to develop a Chemical Hygiene Plan (CHP) which addresses all aspects of the OSHA Laboratory Standard. This plan is to include:

- every aspect of procurement, storage, handling, and disposal of chemicals used in the facility;

- standard operating procedures within each school if an accident or spill occurs;
- requirements for personal protective equipment;
- engineering controls (e.g. chemical fume hoods, air handlers);
- waste disposal procedures;
- Safety Data Sheet access for each chemical;
- oversight of yearly safety training for all teachers and employees;
- expectations for monitoring employee work practices; and
- maintenance expectations for all equipment used to ensure safety.

OSHA regulations state that Chemical Hygiene Plans must be reviewed on a yearly basis. Training on the protocols outlined in the CHP must occur yearly or as new personnel are brought into the division. As people leave positions and roles designated in the CHP, the document should be revised to reflect and shifts or changes in protocols are responsibilities.

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 2015 to reflect the United Nations' Global Harmonizing System, 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. Older students have more 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.

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).

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.

Safety and Science Education in Virginia

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 to conduct safety assessments of the learning environment 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. For each chemical, the inventory should indicate the:

1. chemical name of the substance
2. amount on hand
3. storage location
4. purchase date
5. name of supplier
6. potential hazards
7. program in the chemical is used

The chemical inventory should be computerized for ease of adding or deleting information. Electronic or paper copies of the chemical inventory should be in chemical storage areas and in the main office of the school. If there is an emergency, the fire department will need immediate access to the chemical inventory.

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.

A Safety Data Sheet (SDS) should be on hand for each chemical maintained. SDS should be in all chemical storage rooms. All employees, including the school nurse, should have immediate access to SDS for chemicals that are being used in the classroom.

The Safety Inventory

The safety inventory involves an assessment of the safety features of the laboratory. The safety inventory 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 and tested on a regular basis. 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:
 - a. A list of all laboratory activities scheduled for each science course.
 - b. 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:
 - a. A list of science projects or types of projects that will be sponsored by department personnel
 - b. A statement of rules or regulations governing the construction or production of student projects
 - c. A definition of the working environment in which the student prepares the project (laboratory project room, home basement, etc.)
 - d. A list of the chemicals, materials, and equipment available for students
3. The field trip inventory should include:
 - a. A list of field trips by subject area
 - b. A concise description of the environment for specific field trips (example, biology - natural area studies)
 - c. A list of equipment to be used on field trips (i.e., rock chips, hammers)
 - d. A statement of rules or regulations governing student conduct on field trips
 - e. 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. Evaluate this information 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 immediately or years after exposure. 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. Constantly examine the instructional environment 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 teachers tend 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 can cause injury when misused, and (3) identify the potential injuries that may result. The next section describes some injuries that may result from physical hazards.

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 walkways, 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 Safety Data Sheet (SDS) for specifics on each substance. **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 can 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 SDS 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 blood borne 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 SDS.

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.

Carcinogenic chemicals are the most widely publicized of the health hazards. The Department of Health and Human Services publishes a list of carcinogenic chemicals. These chemicals should not be used in public school science programs. The list, as of 2016, is available from the [National Toxicology Program Website](#).

Some 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.
2. 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.
3. Carbon disulfide is toxic through ingestion, inhalation, or skin absorption. Psychic disturbances may result from long-term exposure.
4. 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

Global Harmonizing System (GHS)

The Globally Harmonized System of Classification and Labelling of Chemicals, also known as GHS, defines and classifies the hazards of chemical products, and communicates health and

safety information on labels and safety data sheets. The goal is that the same set of rules for classifying hazards, and the same format and content for labels and safety data sheets (SDS) will be adopted and used around the world (OSHA, 2016).

In GHS here are three major hazard groups:

- Physical hazards
- Health hazards
- Environmental hazards

Criteria for classifying chemicals have been developed for the following physical hazard classes:










- Explosives
- Flammable gases
- Aerosols
- Oxidizing gases
- Gases under pressure
- Flammable liquids
- Flammable solids
- Self-reactive substances and mixtures
- Pyrophoric liquids
- Pyrophoric solids
- Self-heating substances and mixtures
- Substances and mixtures which, in contact with water, emit flammable gases
- Oxidizing liquids
- Oxidizing solids
- Organic peroxides
- Corrosive to metals

Criteria for classifying chemicals have been developed for the following health hazard classes:

- Acute toxicity
- Skin corrosion/irritation
- Serious eye damage/eye irritation
- Respiratory or skin sensitization
- Germ cell mutagenicity
- Carcinogenicity
- Reproductive toxicity
- Specific target organ toxicity - single exposure
- Specific target organ toxicity - repeated exposure
- Aspiration hazard

Within each of these hazard groups there are classes and categories. Each of these parts is called a building block. Each country can determine which building blocks of the GHS it will use in their different sectors (workplace, transportation, consumers). Once the building blocks are chosen, the corresponding GHS rules for classification and labels must be used. The following diagram shows the Hazard Communication Standard (HCS) Pictogram as identified by the Occupational Safety and Health Administration.

HCS Pictograms and Hazards

<p>Health Hazard</p>  <ul style="list-style-type: none"> ■ Carcinogen ■ Mutagenicity ■ Reproductive Toxicity ■ Respiratory Sensitizer ■ Target Organ Toxicity ■ Aspiration Toxicity 	<p>Flame</p>  <ul style="list-style-type: none"> ■ Flammables ■ Pyrophorics ■ Self-Heating ■ Emits Flammable Gas ■ Self-Reactives ■ Organic Peroxides 	<p>Exclamation Mark</p>  <ul style="list-style-type: none"> ■ Irritant (skin and eye) ■ Skin Sensitizer ■ Acute Toxicity ■ Narcotic Effects ■ Respiratory Tract Irritant ■ Hazardous to Ozone Layer (Non-Mandatory)
<p>Gas Cylinder</p>  <ul style="list-style-type: none"> ■ Gases Under Pressure 	<p>Corrosion</p>  <ul style="list-style-type: none"> ■ Skin Corrosion/Burns ■ Eye Damage ■ Corrosive to Metals 	<p>Exploding Bomb</p>  <ul style="list-style-type: none"> ■ Explosives ■ Self-Reactives ■ Organic Peroxides
<p>Flame Over Circle</p>  <ul style="list-style-type: none"> ■ Oxidizers 	<p>Environment (Non-Mandatory)</p>  <ul style="list-style-type: none"> ■ Aquatic Toxicity 	<p>Skull and Crossbones</p>  <ul style="list-style-type: none"> ■ Acute Toxicity (fatal or toxic)

More information about the Global Harmonized System of classification and the labeling of chemicals can be found through the National Science Teacher Association (NSTA) at [NSTA GHS Classification](#).

The National Fire Protection Association 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 Highly	Extremely Highly
3 High Health Hazard	Moderately Slightly	Moderately Slightly
2 Moderate Health Hazard	Combustible	Nonreactive
1 Slight Health Hazard	Noncombustible	
0 No Significant Hazard		

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

Assignment of Duties

The Division Chemical Hygiene Officer tasks include:

1. Develop and implement the Chemical Hygiene Plan (CHP) and the safety program for the division, including training, reporting and other functions noted here.
2. Work with administrators and teachers to develop and implement the safety program.
3. Maintain a list of School Chemical Hygiene Officer(s) in school buildings where there are laboratories.
4. Work with the School Chemical Hygiene Officer(s) to monitor procurement, use, and disposal of chemicals used in the schools' laboratory programs.
5. Assure that inspections of equipment and space in the laboratory are performed when appropriate and that records of inspections are maintained.
6. Provide technical assistance to schools and employees on the CHP.
7. Assure the CHP is revised as needed to assure that it is in compliance with current legal requirements.
8. Consult qualified individuals regarding requests to use chemicals identified as explosive, carcinogenic, mutagenic, highly toxic, or otherwise unsuitable for general school laboratories.
9. Determine the need for personal protective equipment beyond that specified for general laboratory use.
10. Implement appropriate training annually regarding chemical hygiene for all division employees whose normal work locations include laboratory areas.
11. Conduct annual review and revision of the CHP.

The Building Principal or appropriate personnel tasks include:

1. Provide for the proper maintenance or replacement of facilities and equipment to insure the health and safety of students.

2. 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.
3. Ensure that appropriate instructional techniques and curricular materials are used by the faculty.
4. Provide, with the assistance of the faculty, alternative educational experiences for students whose conduct pose hazards.
5. Implement annual safety training.

The School Chemical Hygiene Officer will be designated by the Principal. The School Chemical Hygiene Officer will serve as the buildings contact person for chemical hygiene programs. The School Chemical Hygiene Officer tasks include:

1. Ensure that employees have received appropriate training.
2. Ensure that employees have access to the CHP, SDS, and other suitable reference materials.
3. Ensure that appropriate inventories are completed and made available to all teachers and administrators.
4. Record, transmit, and follow up all requests for maintenance or replacement of equipment.
5. Assist and support the classroom teacher in determining maintenance needs.
6. Assist and support the classroom teacher in modifying teaching strategies when necessary to improve laboratory safety.
7. 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.
8. 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.
9. Provide regular, formal chemical hygiene and housekeeping inspections.
10. Coordinate requests to the Division Chemical Hygiene Officer and Principal for acquisition and use of chemicals identified as explosive, carcinogenic, mutagenic, highly toxic, or otherwise unsuitable for general school laboratories.

The classroom teacher tasks include:

1. Model safe classroom procedures.
2. Instruct students about the potential hazard(s) of an activity and the appropriate procedures for safely completing the activity.
3. Ensure that all equipment used by students is functioning properly.
4. Ensure that student activities are appropriate for their background and maturity and that safety equipment and facilities are available.
5. Utilize appropriate classroom management techniques to reduce the risk of student exposure to potential hazards.
6. Ensure that all students follow instructions, utilize appropriate procedures, and practice safe behavior.
7. Participate in annual safety training.
8. 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 20-131260 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.
2. 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. 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.

The American Chemical Society (ACS) has published a list of chemicals that should be avoided in K-12 schools. The list was generated by the ACS Safe Practices Subcommittee and includes chemicals that they believe should not be found in a secondary science inventory or used by individuals who are not knowledgeable or skilled in working with high hazard chemicals. The list is included in the document [Reducing Risks to Students and Educators from Hazardous Chemicals in a Secondary School Chemical Inventory \(PDF\)](#). The list is not intended to be a comprehensive list of chemicals that should not be found in a secondary classroom, nor it is an attempt to be a “ban” or otherwise prohibit the proper use of chemicals in the secondary school laboratory. All chemicals should be reviewed yearly as part of the chemical inventory process.

Purchasing

A well-coordinated purchasing program should ensure 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 SDS.

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.
 - a. Time-sensitive chemicals should be purchased only in quantities sufficient for one year.
 - b. Chemical purchases should be determined annually based upon:
 - i. school needs, and
 - ii. a specific chemical shelf life (Reference SDS). 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 updated 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 SDS

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

There are many other considerations when determining safe storage for chemicals and laboratory materials. These considerations include:

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) 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 29 CFR 1910.1450).

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 29 CFR 1910.1450).

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

To prevent fires

1. Have a written emergency plan of your labs.
2. Minimize materials. Have present in the immediate work area only the minimum quantity of materials necessary for the work in progress.
3. Observe proper housekeeping. Keep workspaces uncluttered and clean frequently.

4. Observe restrictions on equipment.
5. Keep barriers in place (shields, hood doors, lab doors).
6. Wear protective clothing and protective equipment.
7. Do not work alone.
8. Store solvents in approved chemical storage cabinets.
9. Shut door behind you when evacuating.
10. Constantly monitor open flames.
11. Keep combustibles away from open flames.
12. Do not heat solvents on hot plates.
13. Remember the “RACE” rule in case of a fire.
 - R= Rescue/remove all occupants
 - A=Activate the alarm system
 - C=Confine the fire by closing the door
 - E=Evacuate/ExtinguishIn operating fire extinguishers remember the “PASS” rule
 - P=Pull the pin
 - A=Aim the extinguisher at the base of the fire
 - S=Squeeze the trigger while holding the extinguisher upright
 - S= Sweep the extinguisher from side to side

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.
3. All persons in a laboratory in which chemicals are to be used should wear approved eye protective devices and protective clothing (aprons, laboratory coats).
4. All persons should wear gloves, goggles, and face shields when chemicals capable of severe tissue damage (chemical burns) are to be used.
5. Body protective devices (laboratory guards, body shields) should be used when an explosion hazard exists.
6. A properly operating fume hood should be used for all chemical reactions that may generate toxic fumes, vapors, or dusts.
7. Chemicals that are highly caustic or corrosive should be used only if an eyewash fountain is available and functioning properly.
8. 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.
9. Double buckets should be used to transport corrosive materials.
10. 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.
11. Students should be instructed in the proper use of poisonous chemicals.
12. 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.

Laboratory Emergencies

Procedures for laboratory emergencies should be developed as described in NFPA45. These procedures should include alarm actuation, evacuation, and first aid for specific types of injuries.

1. Alarm actuation-Notify the designated contact person in the school office. The intercom or classroom phone should be used if available. If the accident imperils more than the immediate class, activate the fire alarm system.
2. Evacuation – The evacuation plan should be written with an accompanying diagram and posted in each laboratory. The evacuation plan should include:
 - a. The conditions under which the laboratory will be evacuated
 - b. The method of contacting the school office
 - c. Action to be taken upon being ordered to evacuate (shut off gas, electrical equipment, close windows and doors)
 - d. Exit routes including an alternate route
 - e. The person charged with counting of students when the class reaches the designated safe zone
3. 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:
 - a. 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, NFPA45 recommends that the student be horizontal to reduce flame damage to face and eyes and to reduce the risk of smoke and heat inhalation.
 - b. 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 safety of students.
 - c. 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.
 - d. 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. Refer to the chemical SDS prior to use to determine water reactivity.
 - e. Electrical shock – Shut off electricity and seek qualified assistance immediately.
 - f. 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.

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

Drain Disposal

Before considering drain disposal, be certain that the sewer flows to a wastewater treatment plant and not to a stream or other natural water course. *Check with the local wastewater treatment plant authority to determine what substances are acceptable for drain disposal.* If you are able to use the drain, the substance from a laboratory should be flushed with *at least* 100 times its own volume of tap water. Acids and bases should be at least above pH 3 and below pH 8 before being placed in a sanitary drain. If both ions of a compound are on the following lists, that compound may be placed in a sanitary drain:

Positive Ions	Negative Ions
aluminum	borate
ammonium	bromide
bismuth	carbonate
calcium	chloride
copper	cyanate
hydrogen	hydrogen sulfide
iron	hydroxide
lithium	iodide
magnesium	nitrate
potassium	phosphate
sodium	sulfate
strontium	sulfite
tin	tetraboratex
titanium	thiocyanate
zinc	.
zirconium	.

The following organic compounds can go into a drain:

acetic acid	ethanol
acetone	ethylene glycol
butanols	glycerol
esters with less than 5 carbon atoms	methanol

oxalic acid

potassium salts of carboxylic acids

pentanols

formic acid

propanols

sugars

sodium salts of carboxylic acids

For additional information on drain disposal of substances, see the [National Research Council's Prudent Practices in the Laboratory](#).

If in doubt about the proper disposal of a chemical, check with the local safety officer or refer to the Flinn Scientific Catalog or a similar reference.

Labeling of Chemicals

Proper labeling of chemicals is another step for insuring safety. Whether stored in the container used in the purchase, or a reagent that is created for the laboratory, proper labeling is required. The label should include the chemical name, and not just a common name. Precautionary statements that include flammability, corrosiveness, reactivity, and explosiveness should be included on the label.

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

Include the following minimum essential information on chemical labels:

- Chemical manufacturer or supplier (including address and telephone number)
- Chemical name and/or trade name of the product
- Date received or date placed in the container
- Strength of the chemical
- Precautions to be observed in handling or mixing the chemical
- Appropriate hazard symbol (NFPA)

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 handling animals and microorganisms, and classroom activities on the school grounds and outdoor study areas.

Effective control of such hazards involves similar considerations to chemical hazards and includes recognition of the hazard, the development of control procedures and the development of first aid measures. As with chemical hazards, teachers should receive annual training on biological and environmental hazards.

Animals in Instructional Programs

Although animals in the classroom can enhance the science learning for students, they can also be hazards. Animals can carry diseases that can be transmitted to humans, and some of these diseases can be fatal. They can also contract and serve as carriers for human diseases. Handling of animals carries the additional risks scratches and bites. Some students may be allergic to certain animals, and animals may adversely impact classroom air quality. Only animals that have a role in instruction should be used in a science classroom. When acquiring the animal, make sure that only certified disease-free animals are purchased from reputable firms. The purchase of animals from local breeders or the use of pet animals is not advised. Animals that are captured in the wild must not be used in school laboratory setting. Only species suited to the learning environment and instructional program should be purchased. Low food consumption and small physical size should be considered in the selection of an appropriate species. Permits may be required for securing and/or keeping certain animals. Check local, state, and federal regulations.

After an animal has been determined to be appropriate for the classroom setting, appropriate housing must be provided. Considerations include:

1. Sufficient size to allow the animals to comfortably perform such natural functions as eating, exercising, and sleeping. The facilities must be sanitary.
2. Feeding and watering equipment that has been selected for ease of cleaning and sanitizing and for suitability for the species.
3. The facilities designed to allow removal of animal waste with minimum disturbance to the animal.
4. Climatic control (temperature, humidity, and air quality) that provides a humane environment for the animal.
5. 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 appropriately washed or sterilized.
 - d. Hands must be thoroughly washed before and after any contact with an animal or its

- environment.
6. Access to animal care facilities should be limited to those individuals directly responsible for the animals.
 7. The appropriate climate for a species must be maintained at all times.
 8. Animals suspected of being ill should be isolated and given proper care.
 9. People who are ill should not be permitted to handle and care for laboratory animals.
 10. Appropriate protective equipment such as leather or rubber gloves should be worn when handling animals.
 11. Only commercially prepared specimens should be used for dissection.

Microorganisms and Biotechnology

The 2018 Science Standards do not require students to use microorganisms in the classroom. If microorganisms are used, be sure that the teachers and students are trained in aseptic technique. Microorganisms should be purchased through a scientific supply company.

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.
 - h. Students and instructors should wash their hands thoroughly before and after conducting laboratory work.
 - i. 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.
 - j. Cultures obtained from soil, mouth, plants, or other local environmental sources should not be used.
 - k. Local, state, and federal regulations should be consulted regarding the safe disposal of cultures.
 - l. 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

Safety is important in more than the classroom, and it extends to work out in the field. Injuries may result from impact, cuts and punctures, poisoning, and allergic reactions. Instructors should conduct a survey of the area before the field study. The survey should include:

- Conditions that may cause students to fall (steep terrain, slippery or unstable rocks)
- Unstable objects overhead, which may fall onto students
- Animal burrows or holes into which students could step
- Footbridges or other elevated crossings that may collapse under student weight
- Deep water or streams with currents strong enough to sweep a student off balance
- Animals capable of attacking and injuring students
- Poisonous, venomous, and infected animals
- Insects and arachnids
- Allergenic and poisonous plants
- Vehicle traffic

Precautionary measures include:

- Mapping the safest passage through the study area
- Confirming that all students are physically capable of participating in the field study (heart condition, severe allergenic reactions, and ambulation difficulties must be considered)
- Obtaining permission from parents for children to be involved in studies off the school grounds
- Avoiding areas which have been sprayed with herbicides or pesticides
- Using school board approved means of transportation

Students should be instructed in:

- Safe methods of personal and equipment transport over the study area
- Recognition and avoidance of poisonous plants and animals
- The use of appropriate foot gear and other clothing
- Safe methods of working in deep or turbulent bodies of water, including the wearing of life jackets
- The proper use of equipment, including the wearing of eye protective devices

Students are to be always supervised by an adult in the classroom and laboratory settings.

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 spillages 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:

- All aisles and exits must be clear at all times.
- Evacuation procedures and alternate routes should be clearly posted in each classroom.
- ABC-rated portable fire extinguishers should be installed in each laboratory in accordance with NFPA-10.
- The extinguishers must be maintained at full charge, checked periodically, and serviced.
- 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.
- All staff should be trained in the proper use of the fire extinguisher and fire blanket.

Emergency Procedures

If a fire starts:

1. Activate the fire alarm and evacuate the area
2. A teacher should shut off the gas and electrical power to the laboratory using the master control switches
3. Close all windows and doors, if possible
4. Do not use a carbon dioxide or chemical fire extinguisher to put out hair or clothing fires
5. Students with clothing fires should be pushed to the floor and rolled to extinguish the flames, or wrapped in a fire blanket
6. 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
7. 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 quantities 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 the direct supervision of the instructor.
2. X-ray sources are a health hazard. The 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. Ensuring 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. Ensuring 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) requires the wearing of eye-protection devices at all times while participating in designated school activities. 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:

1. Vocational or industrial arts shops or laboratories involving experience with:
 - a. Hot molten metals;
 - b. Milling, sawing, turning, shaping, cutting, grinding, or stamping of any solid materials;
 - c. Heat treatment, tempering, or kiln firing of any metal or other materials;
 - d. Gas or electric arc welding;
 - e. Repair of any vehicle;
 - f. Caustic or explosive materials.
2. 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 at 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 Z87.1-2015. 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 §87.1-2015 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 2015.
 - b. The eye protective devices should provide protection against all eye hazards.
 - i. Splash-resistant goggles shall be worn in all laboratories using corrosive or caustic liquids or vapors.
 - ii. 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 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. Exhibits II & III illustrates three 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: _____

Accident Occurred: Date: _____ Time: _____

Location: _____

Name and Address of Injured: _____

Nature of Injury : _____

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

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

Emergency Procedure Taken: _____

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

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 exercise 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.

Business Phone Number:_____ (continued on next page) ‘

Exhibit III

Sample Parent-Student Safety Contract

Laboratory study is essential for the mastery of scientific principles. During lab study, students will be doing activities that may require the use of hazardous materials and equipment. Every student has a right to be in a safe and productive learning environment. Prior to conducting any laboratory work, the attached agreement must be signed by both student and parent/guardian and on file with the instructor. Horseplay, practical jokes, and pranks are dangerous and are prohibited. Unauthorized experiments are not permitted. By entering the laboratory, students agree to follow the instructions of the classroom teacher. Students will read all procedures thoroughly and complete any necessary pre-lab work before beginning. Whenever an injury or accident occurs, students must immediately report the incident to the teacher.

A. Behavior in the Science Classroom

1. Students are not to touch equipment until given proper instructions and permission by the teacher.
2. Students should observe good housekeeping practices. Work areas should be kept clear of books and backpacks. Work areas should be thoroughly cleaned before exiting the lab.
3. Food, drink, cosmetics, and gum are not allowed in the science classroom.
4. Skin must be protected when working with chemicals. Keep your hands away from your face during laboratory work. Right before leaving the lab area, students should thoroughly wash their hands with soap and water.
5. Students wearing short skirts, shorts, sandals, and/or open-toe shoes may be restricted from laboratory work.
6. Students should know what to do in the event of a fire.

B. Laboratory Safety Equipment

1. Students will wear splash-proof safety goggles provided by the school while engaged in certain activities as defined by the Virginia State Code, section 22 10-2: "Every student participating in laboratory work involving caustic or explosive chemicals or hot liquids or solids shall be required to wear industrial quality eye protection devices at all times."
2. Contact lenses are discouraged in the laboratory due to the potential for harmful fumes to flow through the gas-permeable surface. Should a student wear contact lenses, he/she should request goggles without vents for use in laboratory work.
3. Laboratory aprons and gloves must be worn as directed by the instructor.
4. Each laboratory is equipped with specialized safety equipment for use in general and emergency situations. Students are responsible for knowing the location, function, and safe operation of each:
 - **Fume Hood:** Provided for storage and use of volatile, flammable, and fuming chemicals (chemical laboratories).
 - **Fire Extinguisher:** CO₂ or dry chemical propellant tanks used for extinguishing laboratory fires.
 - **Fire Blanket:** A dense, non-flammable material used to smother fires on hair or clothing.
 - **Shower:** A saturating stream of water used to wash off chemicals in the event of a large personal spill.
 - **Eye Wash:** A steady stream of water provided to rinse the eyes, nose, or mouth in the event of a chemical spill.

C. Equipment Usage

1. The cost of replacing glassware or equipment caused by *negligence* could be the responsibility of the student.
2. Students should carefully examine glassware before use. Never heat chipped or cracked glassware.
3. Students should never handle broken glassware with bare hands. Broken pieces should be swept up using a broom and dustpan and placed in the designated broken glass container.

D. Handling Chemicals and Biological Materials

1. All chemicals in the laboratory are to be considered dangerous. Do not touch, taste, or smell any chemicals unless specifically instructed to do so.
2. When diluting acid, be sure to carefully add the acid to the water (not vice versa). This reduces the risk of splashing.
3. Students are to dispose of all used materials according to the instructions of the teacher. Solid waste materials (glass, metal pieces, rocks, et cetera) should not be placed in the sinks. Chemical waste will typically need to be treated and neutralized before disposal.
4. Students should not handle or agitate any live or preserved biological specimens unless specifically directed by the instructor. Students should wash hands thoroughly after handling all specimens.
5. No chemicals or biological specimens may leave the laboratory room under any circumstances.
6. If a chemical should splash on skin, immediately flush with running water and notify the instructor.
7. Should a laboratory emergency arise, students are to stop working, extinguish all burner flames and wait quietly until given instructions by the teacher.
8. Alternatives to animal dissection will be provided for students and will be addressed in classes that have dissections as part of the course. Signed parent acknowledgement of this policy is required in these courses.

E. Heating Substances

1. Students should exercise extreme caution when using a gas burner. Take care that long hair, loose clothing, and hands are at a safe distance from the flame at all times. Safe operation of the gas burner will be discussed, demonstrated, and practiced.
2. Students should exercise care when using an electric heating device, such as a hot plate. Do not use the device if the cords are frayed or the connections are loose.
3. Students should point any substances being heated away from people. Never look directly into the mouth of a piece of glassware that is being heated.
4. Heated metals and glass remain very hot for a long time. You cannot always tell when these materials are hot. Handle with caution.

It is the student's responsibility to come to lab prepared, focused, and ready to work. The instructor reserves the right to remove any student from the laboratory as a response to recklessness or lack of adequate pre-lab preparation. These laboratory safety guidelines are designed to create a safe environment in which exploration can occur. Each student should feel safe and comfortable in the lab and confident in his/her abilities to safely handle lab materials and equipment. Every science instructor has the right to supplement these laboratory rules as appropriate to ensure the safety of all students under their supervision.

Student Agreement: I have read and agree to follow all of the safety rules set forth in this contract. I realize that I must obey these rules to ensure my own safety and that of my fellow students and instructor. I am aware that any violation of this safety contract that results in unsafe conduct in the laboratory or misbehavior on my part may result in removal from the laboratory, a grade penalty for the lab activity, parent conference, and/or administrative referral.

Parent or Guardian Acknowledgement: I am aware of the safety instructions my son or daughter will receive before engaging in any laboratory work. I understand no student will be permitted to perform laboratory activities unless this contract is signed by both the student and parent/guardian and is on file with the instructor. My signature on this contract indicates that I have read this Student Safety Contract, am aware of the measures taken to ensure the safety of my son or daughter in the science laboratory and will instruct my son or daughter to uphold his or her agreement to follow these rules and procedures in the laboratory.

Student Signature	Date
-------------------	------

Parent/Guardian Signature	Date
---------------------------	------

Comments and/or Relevant Health Issues:

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, 2015).
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" (2018 Virginia Science Standards of Learning, K-12 Safety).
4. All electrical installations should conform to the provisions of the national electrical code (NFPA-70, 2018). 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. Access to these utility 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 in the laboratory 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, 2015. Laboratories without conventional windows should have a source of "makeup air." 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-45,2015). 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 the Americans with Disabilities Act (ADA) and ANSI standard 117.1, 2017 in such a manner as to permit use by

people with disabilities.

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. The *Guidelines for School Facilities in Virginia's Public Schools* has the following: "Secondary level science labs should provide 45 square feet per student for labs, and provide 60 square feet per student of a combined lecture and lab space".
12. 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 ensure 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, 2015).

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 materials must be provided with a secure lock system. This would include all chemicals rated NFPA 2, 3, or 4 on health, reactivity, or flammability.
2. Flammable storage cabinets should be constructed in accordance with the requirements of NFPA 30. 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. 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, 2018.

2. 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.
3. Eyewash fountains are recommended for all laboratories. ANSI standard Z358.1-2014 recommends the following specifications for eyewash stations.
 - a. Eyewash should be located within 10 seconds walking time from the location of a hazard (approximately 55 feet). The equipment must be installed on the same level as the hazard (i.e. accessing the equipment should not require going up or down stairs or ramps). The path of travel from the hazard to the equipment should be free of obstructions and as straight as possible.
 - b. The eyewash should be capable of providing a steady 3.0 gallons/minute flow at 30 psi of water for a minimum of 15 minutes.
 - c. The eyewash should have a hands-free, stay-open valve that can be activated in one second or less.
 - d. The eyewash should be identified with a highly-visible sign and the area should be well-lit.
 - e. Water delivered should be tepid (60°F - 100°F).
 - f. The eyewash should be maintained and inspected. Activate eyewash/drench hose units at least weekly. Inspect all eyewash/drench hose units annually for compliance with standard.
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 Z358.1-2014 recommends the following specifications for safety showers:
 - a. Shower should be located within 10 seconds walking time from the location of a hazard (approximately 55 feet). The equipment must be installed on the same level as the hazard (i.e. accessing the equipment should not require going up or down stairs or ramps). The path of travel from the hazard to the equipment should be free of obstructions and as straight as possible.
 - b. The shower should be capable of delivering a flow-rate of 20 gallons per minute at a pressure of 30 psi for 15 minutes.
 - c. The shower should have a hands-free, stay-open valve that can be activated in one second or less.
 - d. The shower should be identified with a highly-visible sign and the area should be well-lit.
 - e. Water delivered should be tepid (60°F - 100°F).
 - f. The shower should be maintained and inspected. Activate shower units at least weekly. Inspect all eyewash/drench hose units annually for compliance with standard.
5. Fire Blankets are recommended for all laboratories.

Additional Resources

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APPENDIX

Safety Observation Form

The following safety observation form can be used to evaluate the laboratory for safety requirements.

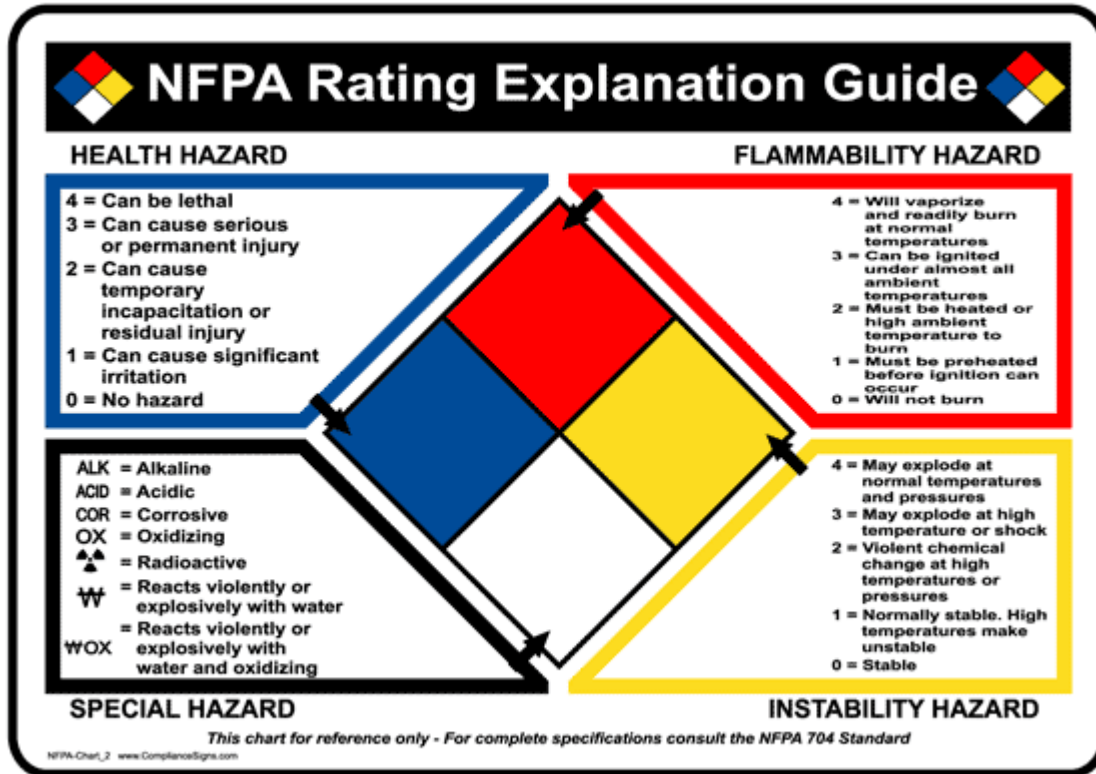
Safety Observation Form

		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.		

		Acceptable	Not Acceptable
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.		

		Acceptable	Not Acceptable
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 using pressure vessels		

National Fire Protection Association Symbols



POINTS OF CONTACT

COMMONWEALTH OF VIRGINIA AGENCIES

[Virginia Department of Education](#)

Virginia Department of Labor and Industry Division of Occupational Health [Virginia Department of Labor and Occupational Health](#)

Commonwealth of Virginia Department of General Services Division of Consolidated Laboratory Services [Consolidated Laboratory Services](#)

[Department of Environmental Quality](#)

[Department of Game and Inland Fisheries](#)

FEDERAL GOVERNMENT OFFICES

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

Department of Labor and Industry Occupational Health and Safety Administration [OSHA](#)

Eisenhower National Clearinghouse for Mathematics and Science Education [ENC](#)

Environmental Protection Agency [EPA](#)

OTHER

American Chemical Society [ACS](#)

American Conference of Governmental Industrial Hygienists [ACGIH](#)

American National Standards Institute (ANSI) [ANSI](#)

Council of State Science Supervisors [CSSS](#)

Flinn Scientific [Flinn Sci](#)

Laboratory Safety Institute [LSI](#)

MSDS On-line [MSDS](#)

National Association of Biology Teachers [NABT](#)

National Fire Protection Association [NFPA](#)

National Institute for Occupational Safety and Health [CDC](#)

National Institute of Environmental Health Science [NIH](#)

National Safety Council [NSC](#)

Poison Control Center 1-800-222-1222

U. S. Fish and Wildlife Services [FWS](#)