Delaware Department of Education

Safer Instructional Practices in the Classroom and Laboratory

Delaware
Department of Education

Safety First: Safer Instructional Practices in the Classroom and Laboratory

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Introduction: Delaware's Safety-First Manual

Ensuring the safety of students, educators, and staff in instructional spaces is a fundamental priority in Delaware's schools. The Safety-First Manual serves as a comprehensive guide for implementing and maintaining safer instructional environments across all grade levels and content areas. From elementary school activities to advanced high school laboratories, the principles of safety are essential to fostering an engaging, productive, and risk-aware learning experience.

Safety considerations in schools are not confined to traditional science or career and technical education (CTE) classrooms. Rather, they extend across all subject areas — including mathematics, engineering, family and consumer sciences, the arts, and more — where hands-on activities and experiences may introduce potential hazards. Additionally, safety awareness is crucial beyond the classroom, encompassing extracurricular activities, student clubs, makerspaces, and Career and Technical Student Organizations (CTSOs) such as BPA, DECA, Educators Rising, FCCLA, FFA, HOSA, SkillsUSA, and TSA.

This manual provides research-based guidance on safety best practices, legal standards, and professional recommendations. It outlines responsibilities for educators, students, and administrators to create a culture of safety that supports hands-on learning while minimizing risks. Topics covered include proper use of personal protective equipment (PPE), emergency preparedness, laboratory protocols, chemical handling, and environmental considerations in instructional settings.

By following the safety principles outlined in this manual, Delaware schools can ensure that every student — regardless of grade level, subject, or extracurricular involvement — has access to a safe, enriching, and innovative learning environment. Whether engaging in a lab experiment, designing a robotics project, or practicing culinary techniques, students and educators alike will benefit from the implementation of Safety-First practices in all educational spaces.

This document is a collaborative effort between the Delaware Department of Education and national safety experts to align with current best practices and ensure compliance with regulatory safety standards. It is our hope that this manual becomes an invaluable resource for maintaining safety as a shared responsibility among all members of the school community.

Acknowledgements

A large portion of the document is adapted from Connecticut High School Science Safety: Prudent Practices and Regulations, © 2008, Connecticut State Department of Education. Used with permission.

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A. Safety Responsibilities of the Classroom Teacher

"Duty or Standard of Care" has been defined as an obligation of a school or its agents (e.g., employees) to ensure one or more individuals behave according to an established legal standard of care to protect those individuals from unreasonable risk or harm that an ordinary/prudent person ought to reasonably foresee (Love, 2014). This means that school staff and school or district leaders (supervisors/administrators) are required to actively anticipate foreseeable harm to students and to others in the school. Furthermore, these leaders are required to take the appropriate actions to prevent foreseeable risks and resultant injuries or damage. "The breach of a particular duty owed to a student or others may lead to liability for both the teacher and the school district that employs that teacher." (Ryan, 2001).

Under duty or standard of care, all classroom teachers must provide a standard of safety in their teaching environments. The Council of State Science Supervisors (CSSS) and other nationally recognized organizations identify three basic duties of the teacher that relate to **laboratory safety:**

- **Duty of Instruction:** adequate instruction before beginning a laboratory activity.
- **Duty of supervision:** adequate supervision of students before (preparation), during (hands-on activity), and after (clean up) such that they behave properly and avoid foreseeable dangers.
- **Duty of maintenance:** assurance that the teacher maintains a safer environment and properly functioning equipment for instruction.

1. Duty of Instruction

The following actions can help educators address their duty of instruction.

a) Posting safety rules prominently in the instructional space. For example, CTE instructional spaces should post OSHA regulations, while health sciences classrooms should display medical regulations, and culinary classrooms should post ServSafe guidelines. (A variety of classroom safety posters are available from suppliers; see Appendix F for examples).

b) Instructing all students in the proper safety procedures for each course before the start of any hands-on laboratory activity, especially if those activities involve potential biological, chemical, or physical hazards.

This instruction must be:

- Accurate,
- Appropriate to setting,
- Appropriate for the maturity of the audience, and
- Current.

This safety training must occur at the beginning of each school year and/or the beginning of each semester.

Students must acknowledge their instruction of safety issues by signing a **student safety acknowledgement form once hands-on safety training is demonstrated by the instructor**. Teachers should continue to assess understanding of safety rules regularly and document such instruction. It is considered a good operating practice to also have parents/guardians sign the **student safety** acknowledgement form. Teachers may document that parents have reviewed the safety expectations by returning the signed contract or through direct parent contact (by phone, email, or letter). It is also better professional practice to document student completion of an instructor supervised hands-on demonstration of the safety practices associated with an item/tool/machine/task/process. ***(These items are mandatory for compliance with Title 14, Regulation 885)***

c) Identifying, communicating, and clarifying any specific hazards involved with individual hands-on activities.
This instruction must include:

- proper handling and disposal of materials
- potential (but realistic) safety hazard analysis associated with each procedure, as well as the resulting risk assessment and safety actions to be followed.
- the necessary course of action/response if a hazardous situation should occur.

2. Duty of Supervision

a) The most effective way to help prevent potential safety hazards in any instructional space is with clear consistent standards of behavior, including fair and consistent consequences for infractions. Misbehavior and horseplay create an unsafe environment for all and must never be tolerated.
b) Students must be supervised by a teacher or other authorized/trained personnel at all times. This is particularly important in laboratory settings.
c) If the teacher is absent from school, hands-on laboratory work must not be left as part of a lesson plan for substitute teachers.
d) Materials for laboratory exercises must be stored securely away from student areas when not in use.
e) The level of supervision must be appropriate to the age of the students, the degree of inclusion, and the hazardous nature of the work.
f) The teacher must ensure that students have adequate workspaces and that all areas where students are working are accessible to the teacher.
g) Remote/distance education and providing materials for home activities can also involve safety concerns involving supervision and an educator's duty of care obligations.

3. Duty of Maintenance

a) All chemicals must be freshly prepared and properly labeled per legal safety standards. Teachers must follow appropriate procedures for proper use, storage, and disposal of all chemicals. (See Chapter 3, General Instructional Guidelines.) ***(These items are mandatory for compliance with Title 14, Regulation 885)***
b) Teachers should only prepare sufficient quantities of working solutions of chemicals to complete a given activity. At the end of the activity, surplus quantities of working solutions should be discarded if they will not be used in a reasonable amount of time. Chemicals must never be left out in the instructional space overnight.
c) Teachers must monitor and arrange for necessary maintenance on any apparatus used in student instruction. Defective equipment must either be repaired or discarded if repair is impossible.

d) Teachers and administrators must work together to keep safety equipment functioning properly. Safety equipment and engineering controls (e.g., fire extinguishers, safety showers, etc.) must be inspected regularly and serviced annually or after use. Teachers must file a written maintenance report, in accordance with district and/or school guidelines, of any defects in the physical environment that might compromise safety directly with the building principal.

e) Teachers must ensure all tools/equipment/machinery have appropriate and properly working safety features, as well as guards. Items that do not have the proper safety features or working guards should be locked out/tagged out until they are fixed.

f) Fire extinguishers must be inspected annually in each school in accordance with district and state fire code guidelines (NFPA regulations). Portable extinguishers must be visually inspected monthly. Teachers must communicate with the Chemical Safety Officer, chief custodian, and/or principal to ensure all fire extinguishers are identified and inspected.

g) Teachers must maintain good housekeeping practices, including appropriate room for egress/exit in the event of an accident and equitable access for individuals according to the Americans with Disabilities Act (ADA). Housekeeping practices should also be implemented to reduce potential slip/fall hazards.

h) Safety rules and procedures should be posted in a visible place. General laboratory safety rules should be included on the safety acknowledgement form that teachers and parents sign. Students must receive training in the appropriate safety measures and safety expectations before any laboratory activities. (Lab safety posters are available from suppliers; see Appendix F for examples).

B. Good Samaritan Act

Any person, who in good faith gratuitously renders emergency care at the scene of an accident or emergency to a victim thereof, shall not be liable for any civil damages for any personal injury resulting from an act or omission by the person rendering the emergency care or as a result of any act or failure to act to provide or arrange for further medical treatment or care for the injured person, except acts or omissions amounting to gross negligence or willful or wanton misconduct. The exemptions from civil liability provided by this chapter shall not apply to the administering of such care where the same is

rendered for remuneration or with the expectation of remuneration or is rendered by any person or agent of a principal who was at the scene of the accident or emergency because he or his principal was soliciting business or performing or seeking to perform emergency care services for remuneration. (*Source: 16 Del. C. 1953, #6801; 58 Del. Laws, c. 105; 59 Del. Laws, c. 361, #1.*)

C. The School Safety Program and the Teacher's Responsibilities

1. The Chemical Safety Officer and the school building principal will be the points of contact in the building for all matters relating to safety issues. It is ultimately the responsibility of the school principal to provide a safe educational environment for all students and staff.

2. Laboratory experiments must only occur in locations with adequate space. Students must have a minimum of 50 net square feet per person of workspace when working in a laboratory or a space where laboratory activities are occurring (e.g., makerspaces). The amount of space required for a given activity may vary, but will additionally depend on the following factors:
    - The nature of the activity
    - The overall design of the instructional space
    - The number, age, and special needs of the students

3. Teachers must advise administrators when there is insufficient space for laboratory instruction or when instruction will take place outside of the normal instructional space. In addition, the work area must be arranged so that the teacher can circulate around the instructional space and supervise students. Compartmentalization (creation of small, secluded workspaces) hampers the teacher from supervising students properly and can lead to improper laboratory behavior going undetected.

4. Teachers must report any hazardous or potentially hazardous conditions in writing to the Chemical Safety Officer, head custodian, and the principal immediately. Teachers must retain a copy of the report and follow up with progress reports as needed until corrections are achieved. Until the hazard has been corrected, the teacher must suspend any laboratory work that could pose a danger to others in the instructional space because of the hazard.

5. The most effective way to ensure adequate safety practices in the instructional space is for safety instruction to occur throughout the year as an integral part of every activity.

6. Teachers must ensure that all safety equipment in the instructional space is well maintained and easily accessible. In particular:
    - Desks do not block safety showers or eyewashes.
    - Fume hoods are not used to store chemicals or other laboratory equipment or materials.
    - Instructional spaces have immediate access to a class ABC fire extinguisher and a fire blanket. These should be in a location that allows access in 30 steps or within 15 seconds. Teachers should communicate with the chief custodian about the location of all fire extinguishers. If a fire extinguisher is deployed at any time for any reason, the principal and the chief custodian must be notified immediately with all relevant details.
      If combustible metals are used (e.g., Na, Mg, K, etc.), a "D" type fire extinguisher must be directly available.
    - Adequate and continuous flowing ventilation appropriate for the laboratory exercise must be maintained. Any work that generates hazardous fumes must be performed in a functional fume hood. (See Safety Data Sheets (SDS) for the specific chemical for more information.)
    - Exits must be easily accessible to all students, especially those with assistive devices (e.g., wheelchairs, walkers, crutches). The evacuation procedure must be explained to students before any laboratory work begins (preferably on the first day of school), and special evacuation arrangements for students with assistive devices must be outlined and submitted to the principal. Evacuation maps should be posted by the exit.

7. Teachers must ensure that students carefully clean up their work area after completing laboratory activities. In addition, teachers must ensure that students wash their hands with soap and water after laboratory work or at any time they must leave the laboratory area as needed.

8. Teachers must never tolerate inappropriate behavior or unauthorized experiments in the laboratory. One person's misconduct poses a hazard to everybody else in the laboratory. Students who engage in physical horseplay, sabotage of others' work, or unauthorized experiments must be removed from the laboratory immediately.

9. Teachers are required to advise students and their parents/guardians of students' rights and responsibilities relating to laboratory safety (safety acknowledgement form, safety tests, etc.). Laboratory safety training must precede all laboratory work and become an integral part of any curriculum that involves laboratory activities. The teacher will obtain and keep documentation that students and parents have been informed of safety expectations.

10. Teachers will introduce the safety program by providing students with a personal copy of the **Student Safety Acknowledgement Forms** that includes a list of *core* safety precautions to be used with students in all courses. Additional precautions that are specific to a course or a laboratory experiment may be added as needed. All students in an instructional space that use chemicals must be trained annually in the safer management of chemicals specific to that area. ***(These items are mandatory for compliance with Title 14, Regulation 885)***

    The training shall include at least the following:
    - An overview of the school safety program.
    - The location of all hazardous chemical containers in the Instructional space.
    - An explanation of how to read labels on containers.
    - The location, availability, and content of Safety Data Sheets (SDS) and an explanation of how they are used.
    - An explanation of the nature of health hazards and physical hazards associated with the use of all hazardous chemicals (regardless of quantity) to which they may be exposed.
    - An explanation of the proper handling, storage, and disposal methods for each of the hazardous chemicals present in the instructional space.

- Measures taken by the instructional staff and school personnel to prevent or control exposure such as engineering controls, personal protective equipment, and emergency procedures for spills or leaks.
- How to deal with potential biological and physical hazards in a safer way using appropriate safety protocols.
- An explanation of how to use related engineering controls in the event of an emergency (school phone, eye wash and safety shower, master power and gas switches, etc.).
- An explanation of evacuation procedures in the event of an accident.

All students should sign a student safety acknowledgement form at the conclusion of this training. (Laboratory safety contracts are available from suppliers; see Appendix F for examples.**)**

11. Teachers shall only conduct laboratory activities that conform to district and/or state curriculum and instruction guidelines and are pre-approved by their district curriculum supervisor for their content area.

12. Careful planning is expected for all activities. The following questions can be used to guide planning for a particular unit or activity:
    - What are the potential safety hazards, resulting safety risks, and appropriate safety actions to be taken?
    - What are the "worst case" scenarios, and how can I prepare for them?
    - What practices, safety equipment (PPE, machine guards, etc.), and protective facilities are prudent and appropriate?
    - Have I performed a “dry run” of the activity to prepare for any potential problems?
    - Is there adequate staff support to deal with unforeseen hazards and resulting risks?
    - Have I received approval from my district curriculum supervisor to conduct this activity?
    - Have I provided all applicable SDS to my school nurse and made them aware of the types of activities being performed and potential hazardous chemicals or materials that will be used?

13. Before any actual laboratory work begins, students should be instructed in emergency procedures, including evacuations. The teacher should review the particular safety rules and procedures most appropriate to the activity and answer all student questions before beginning and then monitor the students' activities closely. Evacuation procedures and directions shall be posted in a clearly visible location for students or visitors to access.

14. Teachers must not leave students engaged in laboratory work unsupervised at any time for any reason. If the instructional space must be evacuated during laboratory work, the teacher must ensure that no hazardous conditions exist before leaving the room.

15. Teachers should only conduct laboratory experiments when a school nurse or medical staff member is present in the building. If teachers are conducting an experiment after the school day (in preparation for later instruction), they should ensure that another teacher is present who is familiar with the potential safety hazards and resulting risks associated with the procedure.

16. Teachers must be aware of any student health concerns that laboratory work may affect. These might include allergies, disabilities, temporary or chronic illnesses, or pregnancy. Teachers should work with the school administration, school nurse, school counselors, school psychologists, and the students' families to obtain current and accurate information. The school must provide this information to the instructor to maintain a safer learning environment for all occupants.

17. Because of the increasing frequency and life-threatening nature of latex allergies resulting from airborne latex particles, many schools have forbidden activities involving latex balloons or latex gloves. This restriction applies to both laboratory work and to teacher demonstrations. Teachers shall ensure that activities do not violate district/school guidelines regarding the use of latex materials.

18. Teachers must report any injury that occurs during a laboratory exercise, however minor, to the school nurse and school administration immediately. Teachers should never administer medication (including topical agents or cough drops) to any student. If the incident is serious enough that the student cannot be moved, the teacher must summon the school nurse and keep the area around the student clear. **As a rule, teachers should not administer first aid to students unless the student's life is in danger.** This typically also applies to administering adhesive bandages for cuts. All situations requiring first aid and medical treatment must be handled by the nurse. (See local district and school policies regarding this topic.*) Only non-latex bandages should be used in case of an emergency.*

19. Teachers must ensure that appropriate laboratory apparel and behavior are observed. Certain lab activities may require the following:
    - Sanitized safety goggles must be worn during certain lab activities with chemical and/or biological hazards (e.g., chemicals, glassware, or heat such as hot plates or open flame).
    - Sanitized safety glasses with side shields can be worn only when dealing with physical hazards (e.g., projectiles, springs, meter sticks, etc.)
    - Goggles and safety glasses must meet the ANSI/ISEA standard Z87.1 D3. Contact lenses are not restricted.
    - Non-latex laboratory aprons should be worn during certain chemistry labs.
    - Non-latex protective gloves should be worn when students handle preserved specimens. Due to allergies, latex gloves should be avoided.
    - Laboratory workers (students) must never eat, drink, chew gum, or apply cosmetics when working in the instructional space.
    - Students with shoulder length hair must secure it behind their shoulders.
    - Students must secure loose fitting clothing and remove or secure dangling jewelry. In special circumstances, medical or religious jewelry should be safely secured so that it cannot dangle from the student's body and create a potential safety risk.
    - Students should not wear artificial fingernails, as they are extremely flammable. Students can wear fire code-compliant gloves to protect their fingers. (See Appendix F for an example of heat-resistant gloves.)

- Teachers are responsible for modeling appropriate laboratory etiquette. Modeling is the most effective teaching method. Visitors to the class (including administration) are also required to use and correctly model any precautions or safety/personal protective equipment (safety goggles, etc.) that are required of students.

20. The district's safety plan shall be reviewed, updated, and made available to all staff members annually.

D. Student Behavior

1. All students must sign a student safety acknowledgement form that outlines the proper safety procedures specific to the instructional space containing biological, chemical, and/or physical hazards.
2. Horseplay or other inappropriate behavior in the laboratory or activity area is forbidden.
3. Instruct students to never taste chemicals or other laboratory materials.
4. Remind students that unauthorized experiments are prohibited. Instruct students to only perform experiments authorized by the teacher.
5. Remind students never to do anything in the laboratory that is not called for in the laboratory procedures.
6. Have students follow all instructions, both written and oral. Provide reminders of safety protocols in the form of posters near potentially hazardous equipment and laboratory areas, and on unit tests and quizzes.
7. Have students report any accident or injury to the teacher immediately, no matter how minor it may appear.
8. Instruct students to never return unused chemicals to their original containers.
9. Instruct students on the appropriate use of personal protective equipment during activity setup, hands-on lab/activity, and take down segments.
10. Remind students to always wash hands with soap and water once the activity has been completed.

11. Remind students that no eating or drinking is allowed in the laboratory instructional space.
12. Students should only use laboratory instructions, worksheets, and necessary equipment in the work area. Other materials such as backpacks, books, purses, and jackets should be stored away from the laboratory work area.

E. Review of Educator Responsibilities:

1. Never leave students unsupervised in a laboratory or other instructional space.
2. Review safety procedures with students before any laboratory work.
3. Take action to ensure student accountability, such as testing of safety procedures.
4. Never overlook any safety infraction. Direct teacher/student intervention supervision is essential.
5. Document all safety planning initiatives (safety inspections, dated safety lesson plans, etc.).
6. Instruct students in the proper use of all safety equipment and personal protective equipment (PPE) before use.

F. Safety Responsibilities of the Chemical Safety Officer

1. Act as liaison among instructional teachers who use chemicals, building and district administrators, and facilities staff regarding chemical safety issues.
2. Maintain the chemical inventory for the school(s). This inventory should be updated at least annually and shared with the building principal(s) and other necessary persons (e.g., local fire marshal, etc.). See Appendix J for a sample Chemical Inventory Form.
3. Review and approve/decline any chemical orders by the district or school.
4. Maintain a supply of Safety Data Sheets (SDS) for all chemicals in the chemical inventory. Share copies of the SDS with the building principal, chief custodian, school nurse, and the local fire marshal.
5. Document and assist teachers with maintenance requests related to safety equipment and issues. This may require calling in a certified technician, licensed professional, or someone from the manufacturer to ensure the maintenance aligns with required safety standards.

6. Identify and coordinate disposal of surplus hazardous chemical wastes. (See also Title 14, Regulation 885, Section 5.0 *Inventory of Chemicals, Hazardous and Non-Hazardous* and Section 9.0 *Disposal of Surplus Chemicals.*)
7. Help develop and implement annual updates for the Chemical Hygiene Plan (CHP), along with providing employee safety training and communication of changes relative to the CHP.

G. Safety Responsibilities of the Administration

1. The school's administration must cooperate fully with teachers and the Chemical Safety Officer to maintain a safer environment for instructional investigations.

2. Principals must ensure that the instructional facilities meet all state and national legal safety standards, as well as better professional safety practices (NSTA, ITEEA, NSELA, etc.). Although laboratory investigation is a crucial part of effective instruction, a safer environment is an absolute prerequisite for any laboratory investigation. This includes provision of appropriate engineering controls (appropriate ventilation, eyewash station, emergency shower, fire extinguishers, fire blankets, etc.) and personal protective equipment (safety goggles with sanitizing goggle cabinets, non-latex gloves, aprons, etc.). Principals must ensure that chemicals are stored in secure storage facilities with limited access.

3. The number of students in an instructional space and the allotted space for laboratory work are crucial components of laboratory safety. As students are scheduled, administrators should work with teachers and school counselors to ensure that classes are small enough to allow adequate room for students to move easily and teachers to supervise students safely. Laboratory occupancy loads must meet legal safety standards (NFPA) and better professional safety practices (NSTA, ITEEA, NSELA, etc.). Research studies have found overcrowded P-12 STEM and CTE laboratories can increase the odds of an accident occurring by 48% (Love et al., 2023).

4. Principals should not routinely schedule science, technology, engineering, or CTE classes in instructional spaces that are not specifically designed for those subjects. If such scheduling is unavoidable, affected classes must have access to appropriate instructional spaces on days when students will conduct experiments or hands-on activities. This arrangement should only occur in temporary or emergency situations. Non-technical and non-science teachers should not be assigned to teach in science or CTE laboratories or makerspaces where there is potential exposure to hazardous chemicals or equipment.

5. Principals must respond promptly to maintenance requests that affect the safety of the instructional space. If there is a delay in processing such requests, the principal must keep the teacher Informed and work with the teacher, curriculum director, and school safety officer to make safety modifications to instructional activities.

6. Administrators should consistently and fairly enforce disciplinary actions for safety infractions based on their severity. If a student repeatedly engages in behavior that poses a safety risk to themselves, their classmates, or the school community, they should be removed from the laboratory. When possible, alternative instructional opportunities with a safer environment should be provided.

7. Principals should ensure that an inventory of all chemicals is in the building and the SDS for each chemical is maintained and easily accessible by appropriate employees. Principals shall ensure that the school building is in compliance with Title 14, Regulation 885 – *Safe Management, Storage, and Disposal of Chemicals in the Delaware Public School System.*

H. Safety Responsibilities of the District Science and CTE Supervisor or Curriculum Specialist

1. Hold periodic safety meetings to address issues relevant to laboratory safety at the instructional space level, the school level, and the district level in conjunction with the Chemical Safety Officer.

2. Assist the Chemical Safety Officer in the preparation and revision of the Chemical Safety Plan.

3. Provide periodic safety training for teachers and keep records of training. Help teachers receive the appropriate training opportunities and any other needed safety resources.

4. In conjunction with the Chemical Safety Officer, maintain records of each school's chemical inventory and provide schools with any necessary SDS sheets. These inventories will be used to assist teachers with maintaining fresh chemicals and safe disposal of surplus chemicals.

5. Attend state level safety meetings and disseminate information from these meetings to district personnel as needed.

6. Assist teachers, the Chemical Safety Officer, and administrators in complying with legal safety standards and best professional safety practices. This may involve recommending appropriate space usage, sourcing safety resources for teachers, and coordinating the purchase, storage, use, and proper disposal of hazardous surplus chemicals.

7. Assist teachers in communicating with school administrators and counselors to determine appropriate laboratory occupancy limits. These limits should be based on net square footage, the nature of activities conducted, and compliance with NFPA 101 safety standards.

References

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CHAPTER 2:
Principles of Safety Practices

Chapter 2: Principles of Safety Practices

A. Five General Principles

To control a person's exposure to chemical, biological, and physical hazards in the laboratory, five general principles for laboratory safety are typically put into place. These include (in order, starting with the most preferred principle):

First line of defense — Elimination of Hazard
Second line of defense — Replacement of Hazard
Third line of defense — Engineering Controls (Environmental Settings/Considerations)
Fourth line of defense — Administrative Controls (Work Practices)
Fifth line of defense— Personal Protective Equipment (PPE)

These lines of defense are represented in Figure 1 below.

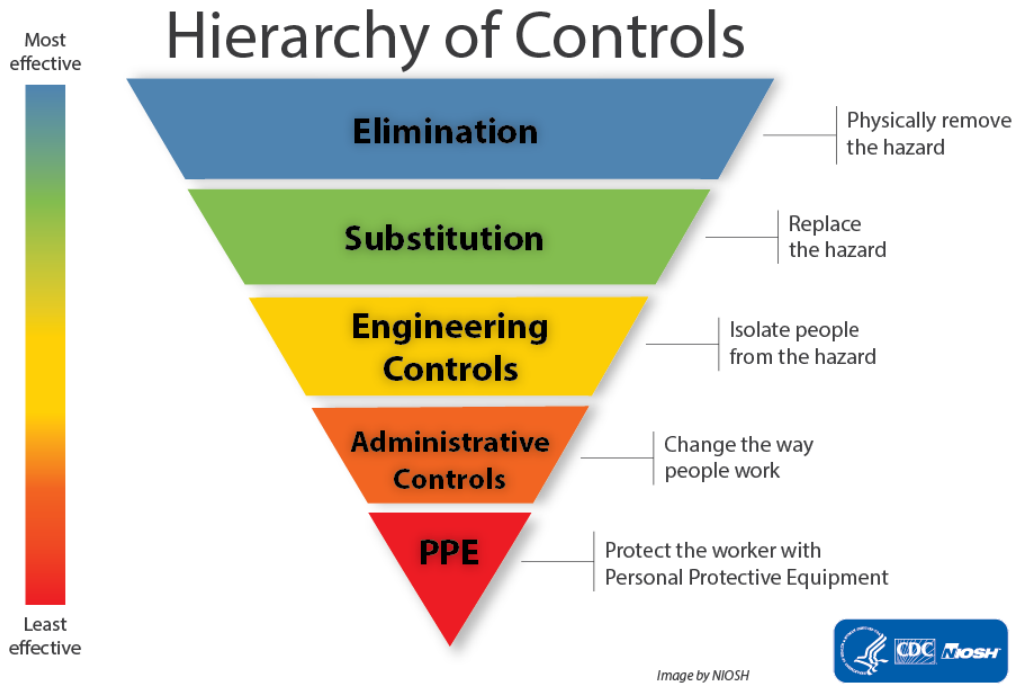

Figure 1: The color gradient on the left indicates that elimination is the most effective control, while PPE is the least effective. The image is credited to NIOSH and CDC.

By designing laboratory and field work using one or a combination of these basic principles, employers and employees can keep their exposure levels well below the permissible exposure limit (PEL).

Explained in more detail below, this hierarchy of defense protects students and teachers from exposure to hazardous chemicals and the resulting risks.

1. **Elimination of Hazard**
   Elimination of the potential hazard is the first step in achieving a safer working/learning environment. Potential hazards with resulting risks that cannot be made safer should be eliminated from use.

2. **Replacement of Hazard**
   Replacement of the potential hazard is the second step or option. It may be possible to replace the hazard with a less hazardous item, based on Safety Data Sheet (SDS) information or other sources. For examples, see:

   - Green Chemistry, Washington State Department of Ecology
   - Transitioning to Safer Chemicals - Why Transition to Safer Alternatives?, OSHA

   Science and CTE classrooms offer other opportunities to improve safety. Replace or sharpen dull cutting instruments, ensure all machines have working safety guards or shields, replace ineffective guards or shields, and ensure that all equipment is grounded.

3. **Engineering Controls (Environmental Settings/Considerations)**
   Engineering controls are the third step or option in dealing with laboratory hazards. These controls remove or reduce exposure to a chemical, biological, or physical hazard by using or substituting engineered machinery or equipment. Examples include the following:
      - Alternate process to minimize interaction with hazardous chemicals, such as using a computer simulation or probe ware.
      - Self-capping syringe needles.

- Use of wet methods to reduce the generation of dust or other particulates.
- Sound dampening materials for reduction of noise levels.
- General laboratory ventilation.
- Isolated exhaust such as a fume hood.
- Radiation shielding.

4. Administrative Controls (Work Practices)

Administrative controls or work practice controls involve changes in work procedures to better protect the employee, student, and other occupants in the room or area of the potentially hazardous activity. This is achieved through written safety protocols/policies/procedures, supervisory activities, and training/resources.

Examples include:

- Housekeeping — Keeping the laboratory work area clear of clutter will reduce the possibility of an accident.
- Prohibiting access to laboratories where hazards such as chemicals, lasers, or ionizing radiation are being used.

5. Personal Protective Equipment (PPE)

In cases where the previous actions or steps are not sufficient, personal protective equipment (PPE) must be used. PPE includes clothing or devices worn to help protect an employee, student, or other occupant from direct exposure to a safety hazard or situation. Examples of PPE include protective clothing (non-latex aprons), hand protection (non-latex gloves), eye protection (indirectly vented chemical splash goggles and/or safety glasses with side shields), and respiratory protection (particulate respirators). Safety Data Sheets (SDS) are a good resource for recommended PPE when working with potential biological, chemical, or physical hazards.

CHAPTER 3:
General Instructional Guidelines

Chapter 3: General Instructional Guidelines

See the Table of Contents for chapters and additional guidelines addressing specific areas of instruction.

A. Science Classroom Layout

General science or interdisciplinary science broadly focuses on scientific research, knowledge, and inquiry. It is the comprehensive approach to basic science literacy. In Delaware schools, curriculum and assessment work toward achieving this goal by exposing students to a myriad of hands-on experiences and study. Hands-on process and inquiry techniques are encouraged through laboratory and field work.

To provide exciting and safer experiences for students, the following legal safety standard specifications and better professional safety practices are highly recommended and, in most cases, required by regulatory agencies (DDOE, OSHA, NFPA, ICC, etc.).

B. Environmental Settings and Considerations

1. Laboratory Footprint

(*These items are mandatory for compliance with Title 14, Regulation 885*)

The work area is the first line of defense for safety by design. This includes the instructional space (indoor or outdoor experimental area), the preparation room, and the chemical storage room.

Footprint safety requirements:

a) There must be separate rooms for the instructional spaces, (laboratory and classroom) activities, and the storage/preparation of chemicals.
b) Furniture placement in laboratories must be designed in such a way as to facilitate easy movement, fast egress, direct observation/supervision, and no trip/fall hazards.
c) All instructional spaces (including classrooms and laboratories) that use potentially hazardous chemicals must have a minimum of two exits. The second exit, for emergency purposes only, can

pass through a non-chemical storage room [adapted from NFPA 101 Life Safety Code, 15.2.5.4].

d) Instructional spaces, including classrooms and laboratories, which use potentially hazardous chemicals, must provide adequate space for student work — a minimum of 50 net square feet per occupant. National sources suggest that student loads not exceed a maximum of 24 students per laboratory [adapted from NFPA 101 Life Safety Code, NSTA recommendations, and research from science education/T&E education/and CTE studies: Love et al., 2023; Stephenson et al., 2003; West, 2016]

e) The laboratory shall be accessible, meeting all ADA requirements for furniture, fixtures, etc.

f) All instructional spaces (including classrooms and laboratories) that use potentially hazardous chemicals must have basic safety equipment that at a minimum includes the following:

- Eyewash (tepid running water, continuous flow style)
- Acid/chemical shower (continuous flow style)
- Eye protection (wrap-around, splash-shield style goggles and/or safety glasses with side shields **meeting the ANSI/ISEA Z87.1 D3** standard as appropriate. (See Appendix F for an example of science safety goggles.)
- Fire extinguisher (type ABC rated for general use and type D for combustible metal use)
- Fire blanket
- Chemical spill equipment

If the instructional area is outside of the physical school building (i.e., a field or outdoor classroom), students must have access to safety equipment in the main building.

Sample Laboratory Layout

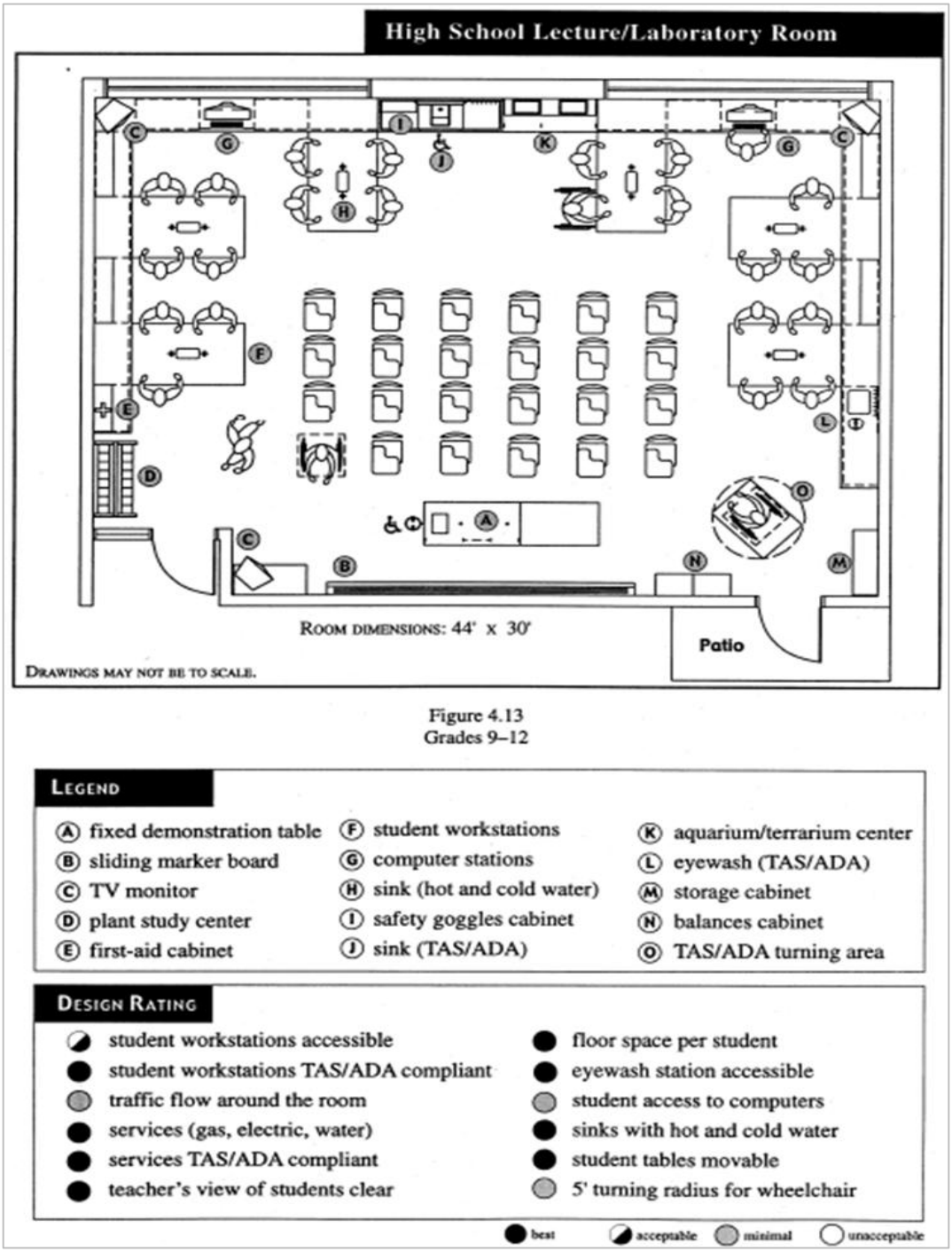

Figure 2: A High School Lecture/Lab Room, Texas Science Facilities Standard (2002)

C. General Guidelines for Instruction and Laboratory Spaces

1. Fume Hood

(These items are mandatory for compliance with Title 14, Regulation 885)

Definition – A fume hood is an engineering control that provides local exhaust ventilation. It usually has a moveable front sash or window with safety glass. The hood is essential in exhausting hazardous gases, particulates, vapors, etc. It protects students, teachers, and other occupants from inhalation exposure.

A properly functioning fume hood and/or other industry-standard ventilation system shall be used when mixing chemicals, using potentially hazardous chemicals, and/or for short-term storage of chemicals that release hazardous fumes. The determination that a fume hood or other ventilation system is necessary shall be based on a hazard analysis/risk assessment and a review of the SDS document(s). This determination should be made in consultation with the Chemical Safety Officer for the school district.

Fume hood safety requirements:

a) Use the hood to remove airborne chemicals, such as aerosols, dust, fumes, and vapors.
b) Hoods are not for storage. Make sure they are easily accessible and keep them clean of chemicals and glassware.
c) Place apparatus as far back to the rear of the hood for efficient air flow.
d) Make sure only necessary materials are under the hood during an operation.
e) Avoid having students work in the opposite direction of a fume hood.
f) Always keep the sash between the operator's face and experiment with the sash lowered.
g) Check the air flow before and during the operation [Face velocity of 80-120 feet per minute (24.4-36.6 meters per minute)].
h) Hoods should be checked regularly and certified operational a minimum of one to four times a year, depending on frequency of use. (See Appendix F for an example of laboratory smoke generators for testing lab fume hoods.)

i) Never block the air flow into or inside of the hood.
j) Do not use the hood as a waste disposal device for organic chemicals.
k) Do not use the hood for explosives, perchloric acid, or radioisotopes.

2. Laboratory Ventilation

(These items are mandatory for compliance with Title 14, Regulation 885)

Ventilation in a laboratory is critical for a safer and healthier operation. Little or no ventilation can allow the buildup of explosive or flammable vapors, respiratory symptoms, and more.

Ventilation safety includes the following:

a) Occupied lab air exchange rates should be six to ten times an hour based on American Society of Heating, Refrigerating and Air Conditioning Engineers (ASHRAE) handbook, or greater than eight air exchanges per hour per NFPA 45. Contact your school facilities director to have the air exchange rate assessed. *(NFPA 45 7.2 requires "laboratory units and laboratory hoods in which chemicals are present shall be continuously ventilated under normal operating conditions.")*
b) Unoccupied lab air exchange rates, including chemical storerooms, should be four times an hour per NFPA 45.
c) Air supplies to labs, storerooms, and preparation rooms should never be recycled to any other part of the building, including other labs, classrooms, and offices.
d) Only conduct experiments that the ventilation system can handle. Otherwise, use a fume hood or select an alternate experiment. Limit occupant exposure.
e) Preventative maintenance programs should be in place to change ventilation filters at least four times a year. Filters typically need to be changed on a quarterly basis.

A good resource for laboratory ventilation is NFPA 45. It addresses required forced air ventilation in science, T&E, and CTE laboratories, including academic labs and other instructional areas**.**

3. Utility Controls

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

4. Alarm Sensors

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

5. Eyewash and Acid/Chemical Shower

(*These items are mandatory for compliance with Title 14, Regulation 885*)

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

All instructional spaces using hazardous chemicals must have an eyewash and acid/chemical shower installed in the space. Acid or safety showers must provide a minimum flow of 30 gallons (113.6 liters) per minute with uninterrupted flow of tepid water.

Eyewashes and showers may have a drain but are not required by code to have floor drains.

Eyewashes are to be inspected (flushed for about three minutes) once a week per the manufacturer's directions to clear out sediment and biological contaminants, etc.

Emergency showers, like eyewashes, are required by ANSI/ISEA Z358.1-2014. Monthly inspections are required. (Put a bucket underneath the shower head and pull the handle.) Monthly signoff sheets must be used; see Appendix F for an example of safety inspection tags.

6. Safety Shields

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

7. Fire Suppression

(***These items are mandatory for compliance with Title 14, Regulation 885***)

Given the dangers of hazardous chemicals and the risks of fire and explosion, fire suppression equipment is an NFPA requirement. Fire extinguishers should be of the A-B-C type (A – combustibles like wood, paper, B – flammables like alcohol, C – electrical, and also type D for combustible metals such as magnesium, potassium, sodium, etc.). If teachers have a laser cutter/engraver in their laboratory, they may ask their school district to install a Halotron fire extinguisher specifically for that machine. This type of fire extinguisher produces a residue that is less likely to damage the machine in the event of a fire. Teachers should be trained annually on the proper use of extinguishers. Check with your district and/or school policy on employee use for fire extinguishers.

Use the following NFPA "**PASS**" approach when using a fire extinguisher:

P – Pull the pin

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

A - Aim low

Point the extinguisher nozzle at the base of the fire.

S - Squeeze the lever

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

S - Sweep from side to side

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

Signs should be posted displaying the locations of fire extinguishers, particularly in instructional areas where they could be easily blocked from view. The signs should be large enough to be seen clearly from a distance.

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

Travel distance for Class D portable fire extinguishers is not to be more than 75 feet (22.9 meters) from the hazard [29 CFR 1910.157(d)(6)]. Travel distance for Class ABC portable fire extinguishers is not to be more than 50 feet (15.2 meters) from the hazard [29 CFR 1910.157(d)(4)].

8. Fire Blanket

(*These items are mandatory for compliance with Title 14, Regulation 885*)
Flame-retardant wool or other types of materials can be helpful in smothering small fires. Never wrap a standing person on fire in a fire blanket. This can create a “chimney effect.” Wall- mounted canisters or boxes with appropriate signage must be used.

9. Goggle Sanitizer

Ultraviolet (UV) goggle sanitizer cabinets take about 15 minutes to sanitize goggles. Goggles must be sanitized if used by more than one student. Alternatives to sanitizers include disinfectants, alcohol, or dish detergent. Goggle sanitizers only address biological hazards (bacteria, viruses, etc.) for safety goggles or safety glasses with side shields. To clean chemical and physical hazards on goggles or safety glasses with side shields, use dish detergent solution or alcohol wipes before using the ultraviolet goggle sanitizer. Also inspect the UV bulb to make sure it is functioning once or twice a year by turning on the sanitizer cabinet and checking for a light blue glow by viewing through the pilot hole opening. Most lamp manufacturers (Phillips, GE, Sylvania, etc.) recommend removing and replacing UV lamps every 9,000 hours or once a year (as part of an annual preventative maintenance [PM] schedule).

10. Electrical Safety Controls

All laboratories, storerooms, and preparation rooms must be equipped with ground fault circuit interrupter (GFCI) electrical receptacles to protect occupants from electrical shock. OSHA mandates GFCIs within 6 feet (1.8 meters) of a water source. However, because water use can occur throughout the laboratory (e.g., aquariums, ripple tanks, wave tanks, etc.), it is advisable to install GFCI receptacles throughout the entire space. Note: GFCIs do not provide protection if both metal prongs are touched while plugging into the receptacle.

11. Chemicals in an Instruction Area

a) Hazard Rating System

(*These items are mandatory for compliance with Title 14, Regulation 885*)

All chemical storage and preparation areas are required to have the NFPA diamond with the highest hazard ratings of chemicals in the room posted on all doors.

NFPA fire diamonds are typically found on chemical labels. They will determine the highest number on the fire diamond posted on the chemical storage room door.

b) Labeling

(*These items are mandatory for compliance with Title 14, Regulation 885*)

All chemical containers must be labeled in accordance with Title 14, Regulation 885. Labels must be legible, in English, and include the chemical/product name and date of purchase. Additionally, labels must clearly display relevant hazard information. When available, the Globally Harmonized System (GHS) should be used for labeling to ensure consistency and safety compliance.

c) Safety Data Sheets **(**SDS)

SDS for all chemicals, hazardous and non-hazardous, must be kept in an easily accessible place. As part of the laboratory safety preparation for an experiment, all appropriate SDS should be reviewed by the teacher and relevant safety information shared with students. SDS must be maintained by the Chemical Safety Officer in a chemical binder, a paper copy of which must be kept in the chemical storage area(s), or in close proximity to the room, and in the principal/administrator's office. A copy should also be provided to the school nurse and the local fire marshal.

The Hazard Communication Standard (HCS) (29 CFR 1910.1200(g)), revised in 2012, requires that the chemical manufacturer, distributor, or importer provide Safety Data Sheets (SDS, formerly MSDS or Material Safety Data Sheets) for each hazardous chemical to downstream users to communicate information on these hazards. The information contained in the SDS is largely the same as the MSDS, except now the SDS are required to be presented in a consistent, user-friendly 16-section format described below:

- Chemical or substance identity, CAS number, synonyms, and company contact information, including emergency number.
- OSHA hazardous ingredient composition and data on components, including exposure limits.
- Health hazards identification, including acute and chronic levels.
- First aid measures for exposure.
- Firefighting measures.
- Accidental release measures.
- Handling and storage, including information on explosive risk, flammability, chemical incompatibility, and special storage requirements.
- Exposure controls (OSHA Permissible Exposure Limits or PELs) and personal protective equipment.

d) Acids

Acids are dangerous and must be handled with extreme care. When diluting acid with water, think “AAA” — ALWAYS ADD ACID TO WATER! Slowly stir and swirl the contents, being watchful of the heat produced, particularly with sulfuric acid. Always wear appropriate PPE — e.g., indirectly vented chemical splash goggles, nitrile gloves, and a non-latex apron or lab coat.

e) Animal Care

See Chapter 6, Biology Guidelines, for additional guidance.

f) Authorized Access

(*These items are mandatory for compliance with Title 14, Regulation 885*)

Authorized teachers, the school/district Chemical Safety Officer, department heads, principals, and trained custodians are the only employees who should have key access to laboratories, preparation

rooms, and chemical storerooms. Do not permit unauthorized persons (e.g., students) in any laboratory, preparation room, or storeroom where hazards exist, (e.g., hazardous chemicals and sophisticated equipment). OSHA considers laboratories, preparation rooms, and storerooms as secured areas.
These areas must be clearly labeled.

g) Chemical Spill Control
(*These items are mandatory for compliance with Title 14, Regulation 885*)

A chemical spill center must be available in the chemical storage room, or in close proximity to it, and should be available to handle small spills in the laboratory. Large spills and leaks require evacuation and the immediate contact of the local fire department's HAZMAT team. A direct means of communications with the front office by phone or intercom must be available.

Spill kits must include:

a) Neutralizing agents for alkali spills (sodium hydrogen sulfate).
b) Pick-up equipment such as a brush, broom, bucket, or dustpan.
c) Personal protective equipment such as nitrile gloves, non-latex apron, and indirectly vented chemical splash goggles.
d) Inert absorbents such as sand and kitty litter.
(See Appendix F for an example of a spill control kit.)

12. Chemical Storage

(*These items are mandatory for compliance with Title 14, Regulation 885*)

a) Chemical storerooms must be kept under lock and key with limited access to appropriate staff only. No students are to access the chemical storage room at any time.

b) Chemicals shall not be stored in the instructional space for a time period extending beyond the end of the school day. At the end of the day, chemicals are to be secured temporarily in locked storage areas or in the chemical storeroom. All long-term chemical storage must be in a properly equipped chemical storage room.

c) A dedicated refrigerator should be used exclusively for properly labeled chemicals, while food must be stored in a separate refrigerator.

d) Chemical storerooms must be properly maintained and kept dry. Roof leaks, should they occur, must be addressed immediately.

e) Chemical storerooms are to have appropriate ventilation (non-re-circulating). It is suggested that the room have a minimum of four room exchanges per hour.

f) Chemical storage rooms must be in a temperature range of 50-80 degrees Fahrenheit. Chemicals must not be exposed to direct heat sources, sunlight, or highly variable temperatures.

g) Shelving must be made of finished wood or other chemical resistant material with a front lip approximately 0.75 inch (1.9 cm) to 1 inch (2.54 cm) high. All chemical storage shelving and cabinets are to be securely fastened to the wall or floor to prevent tipping over.

h) Chemicals must be stored using a system that segregates chemicals by hazard levels and/or class (flammable compressed gases, non-flammable compressed gases, flammable liquids, combustible liquids, flammable solids, corrosive acids, corrosive bases, oxidizers, organic peroxides, spontaneously combustible reactive, water reactive, explosives, and radioactive).

i) Chemicals must be organized by compatibility, not alphabetically. Begin by separating chemicals into organic and inorganic families, then sort them into compatible and related groups. Incompatible chemicals must be stored separately to prevent hazardous reactions. For example, while acetic acid and acetaldehyde may be alphabetically adjacent, they are incompatible and should not be stored together. Reliable resources for chemical storage and compatibility include reference guides from suppliers and the chemicals' Safety Data Sheets (SDS).

j) All chemicals must have a date of purchase on the container. Older chemicals should be used first, and degradation of older chemicals should be monitored.

Examples of storage groups that are related and compatible:

Inorganic Family

- Metals, hydrides
- Halides, sulfates, sulfites, thiosulfates, phosphates, halogens
- Amides, nitrates (except ammonium nitrate), nitrites, azides
- Hydroxides, oxides, silicates, carbonates, carbon
- Sulfides, selenides, phosphides, carbides, nitrides
- Chlorates, perchlorates, perchloric acid, chlorites, hypochlorites, peroxides, hydrogen peroxide
- Arsenates, cyanides, cyanates
- Borates, chromates, manganates, permanganates
- Other inorganic acids (except nitric acid)
- Sulfur, phosphate, arsenic, phosphorus pentoxide

Organic Family

- Acids, anhydrides, peracids
- Alcohols, glycols, amines, amides, imines, imides
- Hydrocarbons, esters, aldehydes
- Ethers, ketones, ketenes, halogenated hydrocarbon, ethylene oxide
- Epoxy compounds, isocyanates
- Peroxides, hydroperoxides, azides
- Sulfides, polysulfides, sulfoxides, nitrites
- Phenols, cresols

Note: *Suggested storage groups are listed as a model only.*

Special Issues to manage when storing chemicals:

- Use of certain hazardous chemicals at the high school level is not encouraged (e.g., isocyanates, arsenates, cyanides, cyanates, and others).
- Corrosive chemicals such as acids and bases must be stored in separate appropriate chemical storage cabinets.
- Nitric acid must be stored in a separate cabinet.

- Lithium, potassium, and sodium metals are highly discouraged for use in the high school setting and must be stored under dry mineral oil.
- All peroxide-forming chemicals (e.g., ethyl ether) must be monitored for age and removed after recommended shelf life.
- Hazardous liquids must be stored within a secondary containment.
- No chemicals can be stored above eye level or on the floor. Heavy items must be stored on lower shelves only.

13. Storage of Flammables

a) Flammable liquids must be stored in National Fire Protection Association (NFPA) approved flammable storage containers and cabinets. These cabinets should be locked if in an area where unauthorized personnel could access them.

b) Flammable and combustible cabinets should not be directly vented. Venting of these cabinets is not recommended or required except for odor control of malodorous materials. The openings on the bottom and top of the cabinets should be sealed with the bungs supplied with the cabinet. If the cabinets are to be vented, vent from the bottom openings and makeup air from the top openings [NFPA 30, 4-3.2].

14. Storage of Pressurized Liquids and Gasses

Pressurized liquids and gasses must be stored and handled according to current OSHA regulations. Storage bottles must be kept to a small “lecture size” container unless the equipment demands a large tank size (gas chromatograph, MIG welder, etc.). Tanks need to be chained to a cart. Lecture bottles need to be in a stand. For more information, see NIOSH’s Compressed Gases - Safety Checklist Program for Schools

15. Inventory Requirements

See Chapter 1, Responsibilities in Instructional Spaces, and Appendix J for explanations and a sample Chemical Inventory Form.

16. Consumer Products/Office & School Supplies

Consumer products and office/school supply products are exempt from hazardous chemical regulations only when they are used as intended by the manufacturer. Products such as hand sanitizer, marker board cleaner, and glass cleaner are therefore exempt, yet care should be taken in the storage of these products. Some consumer products, such as bleach and drain cleaner, may be determined non-exempt as a consumer product if the quantities are large and safer storage of the materials is not available. If the product is shipped with a SDS, it must then be treated as a hazardous chemical. Consumer products and office supplies are governed by the *Consumer Product Safety Act*.

17. Family and Consumer Sciences

Materials used in Family and Consumer Sciences classes must adhere to Department of Public Health Food Code and the ServSafe guidelines for chemical storage.

18. Preserved Specimens

See Biology Guidelines, Chapter 6.

19. Cold/Heat Protection

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

20. De-energizing Equipment

De-energize all equipment when leaving the laboratory and/or instructional area, and before performing any maintenance or adjustments. Examples include unplugging equipment (like microscopes, saws, etc.), shutting off gas valves (use the master gas shutoff), and turning off all water faucets.

21. Evacuation Drills

Establish, provide signage, and practice laboratory evacuation drills. Gas and electricity should be shut off during evacuations using a master power switch.

Keep all exits and safety equipment free from obstructions in any way. No materials can be stored in corridors or walkways.

22. First Aid

First aid kits should be available in each laboratory along with a written phone number for the school nurse's office for medical support in case of an incident. Directions for using the school phone and emergency numbers should be posted directly next to the phone in the event a student needs to make the emergency call. Check with the board of education's policy on employees administrating first aid.

23. Materials in the Classroom Space

Glassware

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

Chipped, cracked, or scratched glassware should never be used in the lab. Broken glassware must be placed in a box or hard plastic container with a plastic liner. Include appropriate signage. Always use glass drying racks to support glassware when drying.

Burners

Never leave an active burner unattended. Never leave anything that is being heated or reacting unattended. Turn off the burner or hot plate when not in use. Give hot items time to cool down before handling. Otherwise, use protective gloves and equipment (tongs, etc.). Flexible connection tubing for Bunsen or other gas burners must meet the American Gas Association (AGA) standard. Latex tubing deteriorates over time and can produce a gas leak resulting in an active flame.

Microwave Ovens

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

Pipette Procedure
Use a suction bulb when filling pipettes, never mouth suction.

Refrigerator
Consumable food must not be placed in the same refrigerator as chemicals or biohazard material. Refrigerators used for non-consumable materials should be labeled "**Contents Not for Human Consumption**" or "**For Chemical Storage Only**". Use appropriate signage on the doors of both types of refrigerators. If refrigerators will be cut off from power for extended periods of time, the teacher and Chemical Safety Officer should work to find an appropriate way to transport and store chemicals or biohazard material in another refrigerator.

Sharps
Pins, knives, utility knives, boxcutters, needle probes, scissors, and shears/snips should be used with extreme care. Sharps to be discarded should be placed in a separate, rigid container labeled "**Sharps Only**."

Signage
Have the appropriate signage installed/posted for the following items: exits, eyewash stations, fire blankets, fire extinguishers, goggle sanitizers, master shutoffs, locked out/tagged out items, safety showers, spill kits, and waste containers**.** (See Appendix F for examples of free laboratory safety signs to download and print.)

24. Waste Disposal
(*These items are mandatory for compliance with Title 14, Regulation 885*)
Dispose of all chemical waste properly as directed by the SDS. Chemicals must never be mixed in sink drains. Sinks should only be used for water and solutions noted by the instructor. Solid chemicals, filter paper, matches, and all other insoluble materials are to be disposed of in properly labeled waste containers. Cracked or broken glass must be placed in a special container labeled for "**Broken Glass**." Knife blades and other sharp objects that need disposed of should be wrapped and secured so that they can be handled more safely. Teachers should notify their school custodian about these items in their trash to avoid potential injury.

Waste disposal or items to be recycled should be done on an annual basis. There must be appropriate storage and labeling of all chemicals. Each year, all Delaware public schools are required to inventory their chemical supply and to identify hazardous chemicals in need of disposal through a licensed chemical waste disposal company. Each school must submit a signed letter, on official school letterhead, stating whether or not the school has surplus hazardous chemicals in need of disposal. The Delaware Department of Education will then compile the lists and make arrangements to work with the school to have the hazardous surplus chemicals properly disposed of through a licensed chemical disposal company. **(See Title 14, Regulation 885, Section 9.0 *Disposal of Surplus Chemicals*.)**

25. Personal Protective Equipment (PPE) Requirements

Eye Protective Devices

(*These items are mandatory for compliance with Title 14, Regulation 885*)

Eye protection is required by Delaware law whenever an activity poses a risk of eye injury or when protective eyewear can help reduce the risk. In science and CTE classes, students working with physical hazards — such as using hammers to break apart geological samples or launching rockets — must wear safety glasses with side shields at a minimum. For activities involving chemical or biological hazards, indirectly vented chemical splash goggles are required. While safety glasses protect the front of the eyes, side shields offer additional protection against hazards from the sides.

The general guide for eye protection is as follows:

Chemical Splash Goggles (indirect vents and ANSI/ISEA impact standard Z87.1 D3) are required when using hazardous liquids or solids. Eye protection should be hygienically cleaned after each use via UV goggle sanitizer, alcohol wipes, or detergent and warm water. (See Appendix F for an example of safety glasses.)

Table 1 lists several examples of potential sources for danger and required type of eye protection.

Table 1: Required eye protection based on potential sources of danger.

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

Face Protection

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

Hand Protection

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

Types of gloves appropriate for secondary schools include:

a) Vinyl (microorganisms and biological material – latex is a known allergen for some people)
b) Butyl rubber (most acids)

c) Cotton (absorbs perspiration)
d) Polyvinyl alcohol (organic compounds)
e) Nitrile rubber (insulates against electricity)
f) Neoprene (solvents)
g) Heat resistant leather (metal working such as casting and welding)

Check Safety Data Sheets for the appropriate type of glove for maximum protection.

For effective glove removal, peel one glove off your hand starting at the wrist, moving toward the fingers. Do not allow the surface of the exposed glove to come into contact with the skin. When the first glove is removed, use it to peel off the remaining one.

Foot Protection

For laboratory work, students should be wearing closed toed shoes or sneakers. No flip flops or sandals are allowed. This protects the feet from falling objects such as spilled chemicals, weights, rocks, etc. In CTE classes, steel toed shoes may be required for some activities (e.g., construction).

Aprons

Non-latex aprons are recommended to protect clothing and skin from spills, splashes, etc. Absorbent type aprons are the best. Ensure that they are the appropriate length.

Clothing

The greatest protection comes from wearing long pants and long sleeve shirts/blouses to protect the skin. The nature of the activity and a review of the SDS will dictate clothing guidelines for students. For some activities such as welding, students should be provided with a flame-retardant jacket to protect from fire hazards and burns.

Resources

- American Chemical Society
- American National Standards Institute
- Association for Career and Technical Education
- Centers for Disease Control and Prevention
- Delaware section of the American Chemical Society
- Flinn Scientific
- International Technology and Engineering Educators Association (ITEEA) Resource Hub
- Making Sense of Laboratory Fire Codes
- National Academy Press
- National Fire Protection Association
- National Institute for Occupational Safety and Health
- National Safety Council
- National Science Education Leadership Association
- National Science Teaching Association
- Occupational Health and Safety Administration

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CHAPTER 4:

Instructional Areas using Rocketry, Mechanical, Electrical, Lasers, and Ionized and Non-Ionized Radiation

Chapter 4: Instructional Areas Using Rocketry, Electrical, Lasers, and Ionized and Non- Ionized Radiation

Please read Chapter 1, Responsibilities in Instructional Spaces.

A. Electricity

The following safety procedures are to be used when working with electricity:

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

o) Unplug all extension cords, string lights, etc. at the end of each day. They are a potential fire and electrical hazard.
p) Proper grounding of flammable solvent containers and equipment is needed to protect against static electricity and sparks. Dry air or low humidity fosters static electricity dangers. Sources of sparks and discharges include:
    - Hot plate temperature controls.
    - Brush motors.
    - Light and other control switches.
    - Pulling plugs on energized circuits.
    - Motion of plastic or synthetic materials, including clothing.
    - Ungrounded metal objects such as screw drivers, metal electrode strips, and aluminum foil.

q. Extension cords should not create trip hazards. (See Appendix F for an example of a cable protector.)

B. Electrostatic Generators

The following safety procedures are to be used when working with generators:

a) Students with epilepsy, heart, or nervous system conditions, or pacemakers should never operate or be in the proximity of an electrostatic generator. Check with the school nurse**.**
b) The generator should only be operated by and under the direction of the teacher.
c) Electronic circuits or devices such as cell phones, computers, and cameras can be permanently damaged by the machine's sparks. Keep cell phones at least 50 feet (15.2 meters) away from the generator.
d) Always use a surge protector in line with the generator's power cord.
e) Never operate the generator near flammable or combustible materials.
f) Never leave the machine operating unattended.

C. Ionizing Radiation

The following safety procedures are to be used when working with radioactive materials:

a) Select only low-level alpha and beta emitters.
b) To prevent accidental entry of radioactive materials into the body, high standards of cleanliness and good housekeeping must be maintained in all laboratories where radioactive materials are present and/or used.
c) Visitors are not allowed without prior approval. (See Appendix F for examples of free laboratory safety signs to download and print.)
d) Table and bench tops should be of a nonporous, chemical resistant material. Working surfaces shall be covered with absorbent paper regardless of the type of surface.
e) Eating or drinking in laboratories that deal with radioactive materials is unsafe and forbidden. Refrigerators will not be used for both foods and radioactive materials.
f) One or more trial runs beforehand with nonradioactive materials are recommended for new procedures and new personnel to test the effectiveness of procedures and equipment.
g) Do not work with radioactive materials if there is a break in the skin below the wrist.
h) Always use gloves when handling more than a few hundred counts per minute. Wear protective clothing (lab coats, masks, shoe covers) as needed.
i) When work is completed, each person will clean up his or her own work area and arrange for disposal or proper storage of all radioactive materials and equipment.
j) Wash hands and arms thoroughly before handling any object that goes to the mouth, nose, or eyes (e.g., cosmetics, foods). Keep fingernails short and clean.
k) Laboratories shall provide special radioactive waste containers. These shall bear the words “Caution: Radioactive Waste” and a warning to janitors against handling them.

D. Non-Ionizing Radiation – Lasers

Non-ionizing radiation consists of electromagnetic radiation that lacks sufficient energy to ionize matter. These may include the use of lasers, microwaves, infrared radiation, and ultraviolet radiation in the physics lab.

Safety rules for non-ionizing radiation include:

a) Before operation, warn all individuals present of the potential hazard.
b) Place hazardous warning signs indicating that a laser is in operation and may be hazardous in conspicuous locations inside and outside the work area and on doors giving access to the area. (See Appendix F for examples of free laboratory safety signs to download and print.)
c) Remove all watches and rings before changing or altering the experimental setup. Shiny jewelry can cause hazardous reflections.
d) Practice good housekeeping in the lab to ensure that no device, tool, or other reflective material is left in the path of the beam.
e) Before a laser operation, prepare a detailed operating procedure.
f) Cover all exposed wiring and glass on the laser with a shield to prevent shock and contain any explosions of the laser materials. Be sure all non-energized parts of the equipment are grounded.
g) Set up the laser so that the beam path is not at normal eye level, i.e., below 3 feet (0.9 meters) or above 6.5 feet (2 meters).
h) Use shields to prevent strong reflections and the direct beam from going beyond the area needed for the demonstration or experiments.
i) Whenever a laser is operated outside the visible range (such as a CO2 laser), a warning device must be installed to indicate its operation. (For more, see Laser Safety Facts.)
j) A key switch to lock the high voltage supply should be installed.
k) View holograms only with a diverged laser beam. Be sure the diverging lens is firmly attached to the laser.
l) Illuminate the area as brightly as possible to constrict the pupils of the observers.
m) The target of the beam should be a diffuse material capable of absorbing the beam and reflection.
n) Do not at any time look into the primary beam of a laser.
o) Do not aim the laser with the eye. Direct reflection can cause eye damage.

p) Do not look at reflections of the beam. These, too, can cause retinal burns.
q) Do not use sunglasses to protect the eyes. If laser safety goggles are used, be certain they are designed for use with the laser being used.
r) Report any afterimage to a doctor, preferably an ophthalmologist who has experience with retinal burns. Retinal damage is possible.
s) Do not leave a laser unattended.

E. Rocketry

Special attention must be given to the following safety procedures when working with model rockets. Due to the nature of the chemicals in the model rocket engine, it is advisable to gain permission from the school administration before purchasing and/or using model rockets in the curriculum. Also check local district and school safety policies addressing rocket use. All engines must be stored in a properly equipped chemical storage room.

a) Use only lightweight, nonmetal parts for the nose, body, and fins of the rocket.
b) Use only commercially made model rocket engines stored under lock and key in an environment that meets the manufacturer's recommendations.
c) To prevent accidental eye injury, place launchers so that the end of the launch rod is above eye level or cap the end of the rod when it is not in use.
d) Always use either safety glasses with side shields or safety goggles with an ANSI/ISEA Z-87.1 D3 rating when launching rockets.
e) Do not tamper with rocket engines or use them for any purposes except those recommended by the manufacturer.
f) Launch rockets outdoors, in an open area and in safer weather conditions with wind speeds no greater than 20 mph.
g) Use a recovery system such as a flame-resistant or fireproof streamer or parachute so the rocket returns safely and undamaged and can be flown again.
h) Launch rockets with an electrical launch system and electrical motor igniters.

i) The launch system should have a safety interlock in series with the launch switch and use a launch switch that returns to the “off” position when released.
j) Use a safe launch distance of at least 15 feet (4.6 meters) away from the launch pad for rockets with up to “D” size engines. Use 30 feet (9.1 meters) when launching larger rocket engines.
k) Establish and review with students a call system to communicate safer launch practices.
l) If the rocket misfires, remove the launcher’s safety interlock or disconnect its battery.
m) Wait 60 seconds after the last launch attempt before allowing anyone near the rocket.
n) Launch a rocket from a launch rod, tower, or rail that is pointed within 30 degrees of the vertical to ensure the rocket flies nearly straight up.
o) Use a blast deflector to prevent the engine’s exhaust from hitting the ground.
p) Do not launch rockets at targets such as tall buildings, power lines, or near airplanes.
q) Never put any flammable or explosive payload in a rocket.
r) Do not attempt to recover rockets from power lines, tall trees, or other dangerous places.
s) Always accompany and supervise students when recovering rockets.

F. Centrifuge Operation

Centrifuges are useful tools in the laboratory but need to be operated safely:

a) Only use a rotor before the manufacturer’s expiration or safe-service date.
b) Keep a rotor use log to prevent overuse. Check the manufacturer’s recommendations or specifications, as the parameters differ from one machine to another.
c) Clean rotors and buckets with only noncorrosive solutions.
d) Always ensure that loads are evenly balanced before doing a run.
e) Stop the centrifuge immediately if vibration occurs.
f) Never leave the centrifuge unattended.
g) If corrosive or alkaline materials have been run or spilled, be sure to wash affected parts of the centrifuge immediately and allow them to air dry.

h) Never attempt to open the door while the rotor is spinning or attempt to stop the rotor by hand.
i) Do not attempt to move the centrifuge while it is in operation.

G. Pressurized and Vacuum Systems

Adopt the following safety protocols when dealing with pressurized and vacuum systems:

a) Always use safety glasses with side shields or goggles with ANSI/ISEA Z87.1 D3 ratings.
b) Procedures should always be conducted inside a hood.
c) Place vacuum apparatus out of harm's way so an accidental hit is minimized. The place of transparent plastic around the apparatus helps prevent injury from flying glass in case of an explosion.
d) Protect vacuum pumps with cold traps and vent the exhaust into an exhaust hood.
e) Assemble vacuum apparatus in a manner that avoids strain, particularly to the neck of the flask.
f) Do not allow water, solvents, and corrosive gases to be drawn into vacuum systems.
g) Avoid putting pressure on a vacuum line to prevent stopcocks from popping out or glass apparatus from exploding.
h) Avoid using mechanical vacuum pumps for distillation or concentration operations when dealing with volatile materials. A water aspirator should be used.

H. Sound

The OSHA Occupational Noise Standard (29 CFR 1910.95) has established a noise action level of 85 decibels (dBA) averaging over eight hours. Wind tunnels, motors, engines, and other laboratory equipment have the potential to exceed the action level. Teachers should monitor sound levels and provide hearing protection for themselves and students.

CHAPTER 5:
Agricultural Science Guidelines

Chapter 5: Agricultural Science Guidelines

A. Agricultural Education Facilities

Agricultural education programs include hands-on and laboratory activities within the instructional space. The facilities for agricultural education must be accessible to all populations, clean, safe, adequate, and appropriate for the instructional program.

The following guidelines should be followed to ensure adequate space:

Facility type and space allocation recommendations:

- Classroom: 25 square feet per student
- Ag mechanics laboratory: 150 square feet per student
- Greenhouse: 70 square feet per student
- Agribusiness lab with computers: 15 square feet per student
- Lab storage: 320 square feet
- Teacher office: 120 square feet
- Classroom storage: 120 square feet

B. Additional Facility Considerations

Locker/storage space for student lab clothes, supplies, and a clean-up/wash basin.

For safety reasons, classes involving instructional space laboratory or shop activities should be limited in enrollment to a size appropriate for the instruction, based on NFPA 101 (National Fire Protection Association) or Life Safety Code, occupancy load requirements, or better professional safety practices.

C. Agricultural Safety Training

Agriculture instructors should ensure that safety training is incorporated into the content of the training program. Safety instruction should include equipment, chemical, fire, and bloodborne pathogens safety.

Safety tests specific to courses shall be given and kept on file for all students.

A safety inspection should be conducted at least annually for instructional spaces (e.g., lab areas, equipment, approved storage for hazardous materials, and field trip experiences).

D. Chemical Safety

The instructional space may include a wide variety of chemical safety hazards. Pesticides, paints, fertilizers, and other hazardous materials must be stored and used appropriately. Students should not have access to chemical storage areas. If student management of chemicals is part of the curriculum, direct supervision is required. Personal protective equipment (PPE) must be available to staff and students and worn when they are exposed to hazardous chemicals.

E. Animal Care

Biosecurity is defined as a system of management practices that prevent or greatly reduces the risk of introducing new diseases to a farm or stable. A good biosecurity program should address the prevention of disease entry and spread on a farm, stable, or home. As with any biosecurity plan, livestock and horse owners should contact their regular veterinarian to discuss what appropriate measures should be implemented in their specific operation.

1. Best Management Practices

Since some animals may not exhibit obvious signs of disease, it is important to understand how diseases are transmitted.
Spread of disease agents:

- Animal to animal
- Animal to human

Different routes of transmission:

- Aerosol – Disease agents are contained in droplets which can pass through the air.
- Direct contact - Disease agents in animals or the environment are transferred from one to the other. Examples: Open wounds, mucous membranes, skin, blood, saliva, nose to nose, rubbing, biting.
- Reproductive transmission - breeding or dam to offspring
- Fomite - Contaminated inanimate object carries agents to other animals. Examples: Brushes, needles, shovels, trailer, humans
- Oral - Consumption of contaminated feed or water, licking or chewing environments containing feces, urine, or saliva.
- Vectors - Living organisms that carry disease agents from one host to another:
  - Mechanical vectors: A vector that simply carries a microorganism with no replication from host to host. Examples: flies and cockroaches
  - Biological vectors: In contrast, microbes must propagate within a biological vector before the biological vector can transmit the microbes. Examples: fleas, ticks, and mosquitoes
  - Vector-borne - Insect acquires pathogen from one animal and transmits to other animal(s)
  - Zoonotic – Infectious agents that can be transmitted between (or are shared by) animals and humans. Examples**:** Brucellosis, Tuberculosis, West Nile Virus, and the Plague.

2. General Prevention Tips

Purchasing and Introduction of New Animals to Herd

- Buy from a reliable source.
- Make sure health records on the new animals are up to date.
- Have a reliable veterinarian in the area inspect the animal(s) before purchase.
- Isolate animals once on your property (30 days is recommended for cattle, sheep, goats, horses, and poultry, and 60 days for swine).
- Provide a pen or stall that has adequate ventilation and is not located near other livestock or horses.
- Do not cross use shovels, feed buckets, brushes, or other equipment between the isolated animal and other livestock.
- Ensure workers clean their hands and boots and change clothes before entering other areas.

Returning from Shows or Exhibits

- Isolate animals once on your property (see above recommendations).
- Use your own trailer to transport animals. If you do not have your own transportation, it is crucial to disinfect all returning animals' hooves before entering your barn or stable.

Limit Contact with Animals

The animal should have limited contact to a neighbor's livestock, to wildlife and wild birds, and stray cats/dogs.

Maintain Secure Fences and Locked Gates

Establish biosecurity protocols for delivery vehicles and personnel coming into a pasture/barn where animals are present.

Keep Up-To-Date Health Records on Every Animal

Regularly review and update vaccination and treatment programs on an annual or biannual basis. Compare established protocols with actual practices to ensure compliance and effectiveness.

Investigate Unusual Signs and Unresponsive Cases

Investigate neurologic, downers, or sudden death. Train farm or stable personnel to report sick animals, inspect animals daily, and clean equipment, boots, and clothing.

Euthanize Terminally Ill Animals Promptly and Appropriately

Remove and render animal(s) and perform necropsy on those that have died from unknown causes.

Resources:

- American Veterinary Medical Association
- Biowarfare and Bioterrorism
- Dairy Facility Biosecurity
- Department of Agriculture Office of Homeland Security
- Livestock and Poultry Biosecurity (Penn State College of Agricultural Sciences)
- Meat and Poultry Hotline: 1-888-MPHotline (1-888-674-6854); Hearing Impaired (TTY) 1-800-256-7072
- National Animal Health Emergency Management System

For information with any applicable law, rule, regulation or standard, or the achievement of discharge levels from agricultural lands, contact Poultry & Animal Health - Delaware Department of Agriculture - State of Delaware.

Resource for safety exams: Laboratory Safety Guide for Agricultural Mechanics (Virginia Tech)

F. Plants

1. Check with the school nurse for potential allergy issues for students. Make accommodations as necessary.
2. Wear **indirectly vented chemical** safety splash goggles, **non-latex** gloves and **non-latex** aprons when working with plants.
3. Never have poisonous plants or plants producing allergens in the laboratory.
4. Inform students about the difference between edible and non-edible plants.
5. No parts of a plant should be tasted.
6. No parts of plants should be burned that have allergen-type oils, such as poison ivy and poison oak.
7. Wash hands with soap and water after working with plants.

G. Field and Outdoor Activities

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

1. Review school district field trip policies.
2. Secure information about student medical needs, allergies, and contact information from parents and the school nurse. All students have the right to be safe and included in all school-sponsored activities, in accordance with IDEA, IEP, 504, and Regulation 817 medications and treatments. Students with complex health needs may require special accommodations including:
    a. Access to emergency medications (e.g. life-threatening food or insect allergies, diabetics, seizures).
    b. Specialized transportation (e.g. wheelchair lifts and air conditioning).
    c. Privacy for treatments (e.g., catheterization, tube feedings, and care that requires nursing judgement).
3. Written permission to obtain help for special needs should also be secured in advance.
4. If laboratory chemicals are used during the field experience, SDS sheets are required on the trip.

5. Communication is essential during field experiences. Bring a cell phone for emergency outreach to school and families.
6. West Nile Virus, Lyme Disease, and other insect-borne diseases are real threats. Dress appropriately (long sleeve shirts, pants, closed-toe shoes, or sneakers) and use repellents for insects. Inform parents in advance about the use of insect repellents to avoid potential allergic reactions.
7. Use indirectly vented chemical splash goggles and non-latex gloves during field experiences where chemicals are used for water testing.
8. Use good sun sense by having students and teachers wear long sleeves, long pants, large-brimmed hats, sunglasses, and sunscreen (SPF 30 minimum).
9. Visit the field trip or experience location before taking students to assess any potential safety hazards.

CHAPTER 6:
Biology Guidelines

Chapter 6: Biology Guidelines

A. Animal Care

NSTA recommends that teachers:

a) Educate themselves about the safe and responsible use of animals in the classroom. Teachers should seek information from reputable sources and familiarize themselves with laws and regulations in their state.
b) Become knowledgeable about the acquisition and care of animals appropriate to the species under study so that both students and the animals stay safe and healthy during all activities.
c) Follow local, state, and national laws, policies, and regulations when live organisms, particularly native species, are included in the classroom.
d) Integrate live animals into the science program based on sound curriculum and pedagogical decisions.
e) Develop activities that promote observation and comparison skills and instill in students an appreciation for the value of life and the importance of caring for animals responsibly.
f) Instruct students on safety precautions for handling live organisms and establish a plan for addressing such issues as allergies and fear of animals.
g) Develop and implement a plan for future care or disposition of animals at the conclusion of the study, as well as during school breaks and summer vacations.
h) Emphasize the importance of not conducting experimental procedures on animals if such procedures are likely to cause pain, induce nutritional deficiencies, or expose animals to parasites, hazardous/toxic chemicals, or radiation.
i) Shelter animals when the classroom is being cleaned with chemical cleaners, sprayed with pesticides, and during other times when potentially harmful chemicals are being used.
j) Refrain from releasing animals into a non-indigenous environment.

B. Biotechnology

Biotechnology is an exciting and relatively new area for coursework in high schools. Observe the following safety procedures when working with biotechnology:

a) Only culture microorganisms obtained from known sources. The only microorganisms that should be used in the science laboratory are those that have been obtained from a known source such as a biological supply house or university laboratory. Students should never culture microorganisms from their own bodies or from surfaces around the building, as it is impossible to know whether these organisms are pathogenic.
b) DNA and microbes should be handled as if they will cause infections.
c) Handwashing hygiene is required before and after laboratory work by washing with antibacterial soap and water.
d) Nitril G gloves, indirectly vented chemical splash goggles, and non-latex aprons are required.
e) Keep fingers away from eyes, nose, and mouth.
f) Decontaminate work surfaces before and after laboratory activities and accidental spills.
g) Use only mechanical pipetting. Never use mouth pipetting techniques.
h) Decontaminate all labware such as glassware that was used in laboratory work by soaking in a 10 percent bleach solution for several hours.
i) Before disposing of biologicals, destroy all experimental microorganisms.
j) For additional information regarding the safer use of microbes in the lab, review the following NSTA safety paper: Tips For The Safer Handling Of Microorganisms In The Science Laboratory.

C. Bloodborne Pathogens

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

Bloodborne pathogens can be transferred in four separate ways:

1. Direct,
2. Indirect,
3. Airborne and
4. Vector-borne.

Direct and indirect are the biggest threats.

- **Direct** — By touching body fluids from an infected person. This includes contact with lesions, open wounds, or sores on the skin. The skin lining of the mouth, nose or throat, and eye contact/ invasion are additional avenues.
- **Indirect** — By touching objects that have touched the blood or another body fluid of an infected person.
- **Airborne Transmission** — While not a common mode for bloodborne pathogens, some viruses and bacteria that affect the blood can become airborne through coughing, sneezing, or medical procedures that generate aerosolized particles. These particles can be inhaled and infect others, particularly in healthcare settings.
- **Vector-Borne Transmission** — Occurs when bloodborne pathogens are carried and transmitted by insects or animals. Examples include mosquitoes transmitting malaria or the Zika virus and ticks spreading Lyme disease. These vectors bite an infected host, then carry and transfer the pathogen to another individual through subsequent bites.

The Centers for Disease Control, OSHA, and other regulatory agencies have clear and prudent practices for this purpose. If blood is needed for instructional purposes, it should be purchased through a science or healthcare company.

D. Dissections

Dissection of animals is strongly discouraged. Instructors need to check with district policies on authentic dissection. Virtual dissection is strongly encouraged. (See the Science Bank.)

It is essential that science educators establish specific and clear learning goals that enable them to appropriately plan and supervise these activities. NSTA recognizes science educators as professionals. It encourages teachers to be sensitive to students' views regarding dissection and to be aware of students' beliefs and their right to make an informed decision about their participation.

When planning dissection activities in school classrooms, NSTA recommends that science teachers:

a) Have an alternative to dissection for students.
b) Plan laboratory and dissection activities that are appropriate to the maturity level of the students.
c) Use prepared specimens purchased from a reputable and reliable scientific supply company. An acceptable alternative source for fresh specimens (i.e., squid, chicken wings) would be an FDA-inspected facility such as a butcher shop, fish market, or supermarket.
d) Conduct dissections in an appropriate physical environment with the proper ventilation, lighting, furniture, and equipment, including hot water and soap.
e) Use personal safety protective equipment, such as gloves, chemical splash goggles, and aprons.
f) Ensure that the specimens are handled and disposed of properly.
g) Ensure that sharp instruments, such as scissors, scalpels, and other tools, are used safely.

E. Electrophoresis

Electrophoresis operates at relatively high voltages. The following safety procedures must be addressed when using this technology:

a) Avoid physical contact with unintentional grounding points and conductors like metal, water sources and jewelry.
b) Always directly supervise the use of the equipment.
c) Use and post appropriate “Danger High Voltage” warning signage on power supply and buffer tanks.
d) Exercise caution in working with power supplies that produce high voltage surges when first energized. Should the electrophoresis buffer spill or leak, stop the operation and clean up the spill immediately.
e) Work should be located on insulated surfaces (i.e., rubber mats).
f) Use ground-fault circuit interrupt (GFCI) receptacles for power.
g) Locate equipment in places where wires will not cause a trip hazard.
h) Inspect equipment before use for cracks, leaks, and frayed wires.
i) Use caution when using the apparatus. A thin layer of moisture can act as a conductor.
j) Electrophoresis devices have cooling components in the apparatus. Do not place gel near cooling components, as it can be a conductor.
k) Always wait 15 seconds for capacitor discharge after shutting off the power supply before making any disconnections or connections.

F. Field and Outdoor Activities

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

a) Review local district and school field trip policies before planning field trip and outdoor activities.

b) Secure medical needs, including those for allergies, from the school nurse and/or families before the activity. All students have the right to be safety included in all school-sponsored activities, per regulations and legal considerations (IDEA, IEP, 504, Regulation 817 medications and treatments, and others). Students with complex health needs may require special accommodations, including:
   - Access to emergency medications
   - Life-threatening food or insect allergies
   - Diabetics
   - Seizures
   - Specialized transportation
   - Wheelchair lifts
   - Air conditioning
   - Privacy for treatments, catheterization, tube feedings
   - Care that requires nursing judgement (refer to district requirements)

c) Obtain prior approval for extra accommodations. Permission to obtain help for special needs should also be secured in advance.
d) SDS sheets are required for field/outdoor activities.
e) Communications are essential during field and outdoor activities. Bring a cell phone with emergency numbers.
f) Insect-borne diseases are real threats. Appropriate dress (long sleeve shirts, pants, closed-toe shoes, or sneakers) and insect repellents should be used.
g) Make sure that you have informed parents in advance about the use of repellents, so that potential allergies can be avoided.
h) Establish a code of conduct for participation in field/outdoor activities.
i) Use chemical splash goggles and non-latex gloves when working in the field with water chemicals or other materials.
j) Dress appropriately for the weather (i.e., sunscreen-SPF 30 minimum, winter coat, large brim hat).
k) Visit the outdoor or field site before bringing students to assess if there are any potential safety hazards.

G. Heat Sources

Autoclaves/Pressure Cookers

Autoclaves are dangerous given high pressures and temperatures. Use the following safety precautions:

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

Pressure cookers are less expensive than autoclaves and may be useful in simple laboratory sterilization procedures. However, they can be equally as dangerous as autoclaves. Apply the following safety precautions when using pressure cookers:

a) Always inspect the device to make sure clamps are securely attached, the gasket seal is in place, and the vent tube is clear.
b) Make sure the vent tube is clear and operational.
c) Never touch the cooker until it is cooled down.
d) Never leave the cooker unattended during operation.

Bunsen Burners

Bunsen burners can be dangerous. Apply the following safety precautions when using burners:

a) Make sure hair is tied back.
b) Always wear indirectly vented chemical splash goggles.
c) Light the burner at arm’s length using an igniter or splint.
d) Do not operate the burner with acrylic nails. Hand protection may need to be required.
e) Never leave the burner unattended.
f) Do not touch the burner until it has had time to cool.
g) Do not touch any part of the burner while igniting it.
h) Ensure the gas nozzle is off after using the burner.

Hot Plates

Hot plates are a heat source in biology laboratories and are less dangerous than burners. Apply the following safety precautions when using hot plates:

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

H. Microbes

The study of microbes in the laboratory requires special precautions. Apply the following safety precautions when using microbes:

a) Wear personal protective equipment such as chemical splash goggles, non-latex lab coat or apron, and non-latex gloves.
b) Cover all open wounds with bandages and gloves.
c) Wash the work area with disinfectant before and after laboratory activities.
d) Food or drink is not allowed in the laboratory.
e) Keep sources of contamination such as pencils, hands, and laboratory equipment away from body orifices.
f) Prepare disinfectant trays for the discarding of contaminated materials such as pipettes, Petri dishes, etc.
g) Should there be an accidental spill of microbial organisms, immediately contain it with dry paper towels. Sterilize the paper towels and disinfect the area of the spill.
h) Students should report any accidents immediately to the instructor.
i) Only laboratory grade cultures from a reputable scientific supplier should be used in the laboratory. No general survey collections should be cultured given the danger of pathogenic organisms. An effective alternative can be commercially prepared slides.
j) All bacteria cultures and Petri plates should be autoclaved or microwaved before disposal.
k) Wash hands with antibacterial soap and water after completing the laboratory work and cleaning up.

For additional information regarding the safer use of microbes in the lab, review the NSTA safety paper Tips For The Safer Handling Of Microorganisms In The Science Laboratory.

I. Microwaves

Microwave ovens can be used as both a heating source and decontamination device. Apply the following safety precautions when using microwaves:

a) Never operate the microwave oven when empty.
b) Always check the door seal before use to make sure it does not have a breach.
c) Persons with pacemakers should not be near the oven when operating.
d) Never place metal objects such as aluminum foil in the oven.
e) Do not put your face near the oven door while it is in use.
f) Make sure the inside surface of the microwave is clean.
g) Post proper signage warning of microwave use.
h) Do not place a sealed container full of liquid in a microwave.

J. Plants

Plants can produce toxic substances. Follow the safety plan when conducting experiments dealing with plants:

a) Check with the school nurse for potential allergy issues for students. Make accommodations as necessary.
b) Wear chemical safety splash goggles, non-latex gloves, and non-latex aprons when working with plants.
c) Never have poisonous plants or plants producing allergens in the laboratory.
d) Inform students about the difference between edible and non-edible plants.
e) No plant part should be tasted without specific direction from the teacher.
f) No parts of plants should be burned that have allergen-type oils, such as poison ivy and poison oak.
g) Wash hands with soap and water after working with plants.

K. Refrigerators

The study of biology sometimes requires the use of a refrigerator. Apply the following safety precautions:

a) Never store food in a refrigerator or freezer that has been used to store chemicals.
b) Refrigerators and freezers should be cleaned out and inspected on a regular basis (at least monthly).
c) Containers placed in a refrigerator or freezer should be completely sealed or capped, securely placed, and labeled.
d) Avoid capping materials with aluminum foil, corks, glass beakers, and glass stoppers.
e) All liquid chemicals should be stored in plastic trays.
f) All specimens should be stored in plastic bags with labels.
g) All items stored are to be appropriately labeled.
h) Review the inventory of refrigerator/freezer contents to ensure compatibility of the contents.
i) Store only chemicals in amounts needed over a reasonable amount of time. Each chemical has a shelf life. Decomposition of chemicals can be hazardous.
j) Remember that power outages can have an impact on stored contents. Be aware of unusual odors or vapors.
k) Do not stack materials too high.
l) Petri dishes/plates should be taped together and placed in a plastic bag.
m) Do not use graduated cylinders or volumetric flasks to store materials.
n) Refrigerators/freezers should be periodically inspected (i.e., at least monthly).
o) Maintain an up-to-date inventory on the refrigerator door.
p) If infectious material is spilled, clean immediately with a disinfectant agent such as 70 percent isopropyl alcohol and wipe down the area with soap and water.
q) The refrigerator/freezer must be properly grounded.
r) Do not use extension cords for operating a refrigerator or freezer.
s) Refrigerators/freezers must not be located near lab exits.
t) Always label refrigerator doors appropriately.
    a. See Appendix F for an example of safety signs for refrigerators.

CHAPTER 7:
Career and Technical Education Guidelines

Chapter 7: Career and Technical Education Guidelines

The Career and Technical Education (CTE) encompass a wide variety of student pathways, each with their own unique safety challenges. In most cases, these areas self-impose industry standard and/or OSHA standard safety practices, so students are adequately prepared for post-secondary programs and the workplace.

Hazardous tools, machines, materials, and chemicals can be inherently part of the educational programs in these areas. Some materials and chemicals (i.e., oil, antifreeze, paint, dye, etc.), if used in accordance with the manufacturer's instructions, may be exempt from special storage recommendations provided that the manufacturer's safety and storage requirements have been met. However, the manufacturer's safety and storage requirements do not eliminate the need for demonstrations on how to use the items safer, direct supervision of students when using the items, as well as inventorying and securing items to prevent theft or misuse (See also Chapter 3, General Instructional Guidelines).

Student use of tools, machines, materials, and chemicals as well as student access to these items must always be directly supervised. Teachers must also ensure that the level of access is appropriate for the specific curriculum. Use Chapter 3, General Instructional Guidelines, and the manufacturer's safety instructions as resources to determine safer management of the tools, machines, materials, and chemicals used in the specific CTE laboratory/workplace.

Due to the diverse pathways in Career and Technical Education, this manual cannot list all safety requirements for every course. However, many biological, chemical, and physical hazard safety practices outlined in this ***Safety First Manual*** *apply and should be followed.*

If a specific course guideline is not included, industry standards, OSHA regulations, and best practices must always be observed.

A. General Safety Practices

Personal protective laboratory practices and equipment considerations are laboratory procedures, practices, and equipment that are generally accepted by laboratory health and safety experts as effective, or that the educator can show to be effective, in minimizing the potential for individual exposure to risk.

1. Body Mechanics

a) Use proper muscle groups and distribute the workload.
b) Use both hands to pick up heavier objects.
c) Request help to lift heavy objects.
d) Pushing is preferred to pulling.
e) Use your leg muscles to lift heavy objects rather than your back muscles.
f) Avoid bending and any unnecessary twisting of the body for any length of time.
g) Work should be done at the proper level, and items should be stored at the proper level (e.g., heavier items should be stored lower to the ground in accordance with manufacturer's guidelines).
h) Two people should be used to carry long pieces of stock or material.
i) Do not lift heavy loads above shoulder level.
j) Use appropriate personal protective equipment (PPE) and supports or braces to assist with lifting heavy items.
k) If you have any doubts or questions about lifting, moving, or storing items, contact your school facilities office to develop a safer plan to lift or move the items.

2. Personal Protection

a) Confine long hair so it is not exposed to machinery and does not interfere with vision (e.g., tie back with a hair tie, in some culinary settings a hair net may be appropriate).
b) Require the appropriate use of ANSI/ISEA Z87.1 D3 rated indirectly vented safety goggles, safety glasses with side shields, or other required eye protection (e.g., welding helmets) when conducting laboratory activities or in the same room where they are being conducted.
c) Provide respirators for use where harmful dust or fumes are present and manufacturer regulations call for such PPE.

d) Respirator use requires appropriate certification, fit testing, and supervision to ensure that proper fit, training, and inspection are all taking place.
e) Communicate with your school district's special education department to understand the physical abilities of all students so they will not be assigned tasks which could be detrimental to a student's health based on their abilities.
f) Prohibit the wearing of loose or baggy clothing in the laboratory and shop areas which could get caught in equipment, flames, or hazardous areas.
g) Require students to remove rings and other jewelry while working in the laboratory and shop areas. One exception is medical ID and/or religious jewelry if they do not present a safety hazard (e.g., a student should be asked to tuck a religious necklace inside of their shirt and use athletic tape to secure it to their chest to avoid it from coming loose and getting caught in work area).
h) Areas where noise levels are excessive over long periods of time require the use of appropriate ear protection.

B. Environmental Considerations

Environmental considerations are the elements in an academic laboratory or shop setting where safeguards and safety procedures need to be in place for students and teachers. The laboratory is an instructional area where tools, machines, materials, and chemicals are used to innovate and produce products or prototypes.

The following considerations shall be applied in academic laboratory and shop environments.

1. Facility Condition

a) Aisles, machines, work benches, and other items must be arranged to conform to safer practices.
b) Stairways, aisles, and floors are maintained, clean, dry, and unobstructed with no protruding objects.
c) Walls, windows, and ceilings are clean, maintained in good repair, and free of protrusions.

d) Lighting is safe, sufficient, and well placed. General lab space suggests a minimum of 75-foot candles of lighting. Depending on the activities, additional lighting may be needed.
e) Ventilation and temperature controls should be used to ensure proper conditions. This is extremely important during winter and summer breaks, when equipment may rust, or when chemicals/biological hazards require specific conditions for safer storage.
f) Fire extinguishers and other necessary fire equipment should be properly selected and inspected annually by the school district's facilities manager. Fire extinguishers should be located within 10 second access from where potential fire hazards exist. Different classes of fire extinguishers may be needed based on the activity being conducted.
g) Exits are properly labeled and illuminated.
h) Lockers and drawers are clean, free of hazards, and doors can be kept closed.
i) School personnel know the procedures for notification of a fire and safer evacuation of premises.
j) Laboratories, shops, and other work areas are free from excessive dust, smoke, and airborne toxic materials.
k) Utility lines and shutoffs are properly labeled.
l) Stairways, floor openings, and overhead storage areas are properly guarded with rails and toe boards and have the proper clearances. Access to these areas should be secured or chained off to better supervise safer access to these areas and the items in these spaces.
m) Laboratories, shops, and classrooms should have appropriate safety signage indicating exits, engineering controls, hazardous work areas, PPE requirements, and safety posters to serve as a reminder near potentially hazardous equipment or work areas.
n) Facilities should be designed with the greatest potential hazards in mind. For example, if students need to access a computer lab, it is not ideal to place the computer lab area in the back of the facility so they have to walk through the lab area to get there. It would be safer to design the facility so students can access the computer lab first and then enter a lab area where they could potentially encounter projectiles or other hazards and need to wear appropriate PPE.

2. Facility Size

The size, shape, and arrangement of a facility as well as the location of passageways, storage, and work areas are important factors in establishing a safer working environment. The number of students that can be safely placed into the instructional program may vary with the program requirements, activities, required equipment, number of trained instructors and support staff, and other factors. Some programs that involve large equipment (e.g., milling machines) and moving long materials that will be cut and shaped for prototyping activities may require more room per student. Other programs where the students are not engaging in lab activities may require less square footage. NFPA 101: Life Safety Code requires 50 square feet per occupant when lab activities are being conducted; however, research has shown that 60 square feet per occupant is more beneficial. Research has also shown that regardless of how much square footage is in a CTE or STEM education laboratory facility, once a teacher has more than 24 students to supervise without additional assistance, the chance of an accident increases by 48% (Love et al., 2023). In summary, if the number of students placed in the instructional space exceeds the required square footage cited in the NFPA 101 Life Safety Code, or exceeds 24 per instructor, the potential for accidents will significantly increase and put the school district and instructor — and their students — at risk.

3. Housekeeping Practices

a) Provide for the proper storage and daily removal of all sawdust, metal cuttings, rags, and other waste materials.
b) Provide properly marked boxes, bins, or containers for various kinds of scrap stock and rags.
c) Use sturdy racks and bins for material storage, arranged to keep material from falling on students and to avoid injuries from protruding objects.
d) Employ a standard procedure to keep floors free of oil, water, and foreign material.
e) Ensure appropriate cleaning of equipment and facilities take place after each use.
f) School districts should provide regular custodial service in addition to an instructor's and students' end of class cleanup.
g) Teachers should coordinate with custodial staff to ensure the safe disposal of used blades and other hazardous items.

h) Prohibit the use of compressed air to clean clothing, equipment, dust/shavings, and work areas.
i) Keep walkways and work areas free of all obstructions.
j) Floor surfaces must be maintained in a “nonskid” condition.
k) Tools and materials must be stored orderly, securely, and safely.
l) File cabinets, bookshelves, and other tall cabinets/selves must be securely anchored.

4. Tool and Powered Equipment Considerations

Injuries in CTE and science laboratories or shops can easily occur with the improper use of tools and equipment. Therefore, training and supervision is essential for safer use and supervision. The following considerations should be applied to the use of tools and equipment:

a) All equipment should be operated according to the specifications in the owner’s manual. Instructors should not modify equipment to impede safeguards designed by the manufacturer or change the operation of the equipment or tool in an unsafe manner.
b) Machines and apparatus are to be arranged so operators are protected from hazards of other machines or passing individuals.
c) Point of operation zones are properly labeled and guarded.
d) Permanent enclosure guards are to be installed to properly protect users from pulleys, gears, belts, and other hazardous parts as specified by the manufacturer.
e) Guards should only be removed for repairs and only when the machine is powered off, de-energized, and unplugged or the breaker is switched off. Guards must be replaced immediately after repairs.
f) Equipment control switches for each machine are to be easily available to the operator.
g) Machines must be turned off when unattended or when the instructor leaves the room. If the instructor will be absent, they must shut off power or remove keys from all equipment unless a qualified substitute or certified instructor is present and has district approval to oversee laboratory activities.
h) Proper cleaning equipment is to be used (avoid using compressed air for cleaning purposes).
i) Nonskid strips or mats are to be installed near dangerous equipment and kept clear of debris.
j) A preventive maintenance program is to be established for all equipment.

k) Machines are to be guarded to comply with manufacturer's recommendations and OSHA standards.
l) Cutting tools are to be kept sharp, clean, and in safe working condition.
m) All hoisting devices are to be maintained in a safe operating condition, with specified load ratings easily identified.
n) Machines that are defective or being repaired are to be clearly marked and made inoperable by locking out/tagging out the machine power switch.
o) Machines and apparatus are to be marked with proper color coding (see Item 9, below, for examples).
p) Equipment cords and adapters are to be maintained in a safe working condition. Instructors should contact their district's electrician to make any electrical repairs to equipment or the facility.
q) Modification and repair beyond normal operating maintenance of any machine is restricted to persons certified to make such repairs and modifications.
r) Ladders are to be maintained and stored safely (e.g., anchored to wall).
s) Machines designated for a fixed location are to be securely anchored. Portable machines that are required to be anchored according to the manufacturer's recommendations (e.g., portable band saws) should be anchored in a way that they can be safely clamped down for safe operation while still allowing the equipment to be moved when finished.

5. Safety Zones

In a laboratory, safety zones are used to signify that caution should be exercised to protect the user(s) in this space and to isolate areas of the laboratory for safe traffic lanes. Safety zones are extremely important, as they have been found to significantly reduce the odds of an accident occurring in CTE and STEM education laboratory courses (Love et al., 2023).

a) Major aisles must be a minimum of 3 feet wide, and safer professional practices suggest they be 4 feet wide. All other traffic lanes should be 3 feet wide (including access to engineering controls electrical breaker boxes).

b) A minimum of 3 feet on each side of stationary power machines is recommended. Equipment involving larger material (e.g., table saw and a sheet of plywood) will require additional space for safer operation.
c) Laboratories should be arranged by the activities involved. Paint, welding, machining, and foundry areas should be isolated from each other. It is extremely important to know the different hazards that are present and how they may interact with each other. For example, a welding and metal working area with metal grinders should not be placed near an area involving saw dust, paint fumes, or other flammable airborne particles.
d) Machines that exceed 4 feet in height should be placed in close proximity to walls and appropriately anchored in accordance with manufacturer's recommendations.
e) Attention should be given to the direction of chip throw and kickback of machines. These potential danger zones should be marked.

6. Recordkeeping

a) Always keep an adequate record of accidents and close calls. Report these accidents on the same day through proper channels in your district.
b) An analysis of accidents should be conducted for the purpose of safety improvement and corrective action when warranted.
c) Instructors and school districts should consider students' and parents' privacy in any incident or accident.
d) Instructors should work with their school district's faculty union representative, liability insurance company, and personal legal counsel to address any issues related to safety incidents or accidents.
e) School districts should work with their legal counsel to secure the appropriate documentation to address any issues related to safety incidents or accidents.
f) Also see Chapter 1, Responsibilities in Instructional Spaces, and additional recordkeeping practices.

7. Hand Tools

a) Instruct and ensure students select the right tools for each job.
b) Establish regular tool inspection procedures to ensure tools are maintained in safe condition.

c) Instruct and directly supervise students in the correct use of tools for each job.
d) Provide properly secured storage facilities for tools and equipment.
e) Do not place tools on operating machinery or equipment.
f) Keep tools out of aisles and working spaces where they may become tripping hazards.
g) Do not put sharp objects or tools in pockets. This could result in cuts.
h) Demonstrate and supervise the appropriate transportation of tools and materials in a classroom or lab. When possible, ensure the tool and material storage area is close to the work area to limit travel.
i) For additional tool related safety information, please see the following sources:
    a. ITEEA's Safety Resources and Tests
    b. OSHA Hand and Power Tools
    c. Chapter 10, Technology and Engineering Education Guidelines

8. Scaffolds and Lifts

a) The footing or anchorage for scaffolding and lifts are sound, rigid, and capable of carrying the maximum intended load without settling or displacement.
b) Unstable objects such as barrels, boxes, loose bricks, or concrete blocks cannot be used to support scaffolding, planks, or lifts.
c) No scaffold should be erected, moved, dismantled, or altered except under the supervision of the instructor. No lift should be moved or set up without the supervision and approval of a trained instructor.
d) Scaffolds with open sides and ends must have guardrails to prevent falls. Additionally, scaffolds are to be fully planked or decked, with guardrails installed at heights of 10 feet or more.
e) Scaffolds and their components are to be capable of supporting without failure at least four times their maximum intended load.
f) All platform planks must be overlapped by at least **12 inches** or securely fastened to prevent movement.
g) A secure access ladder or an equivalent safe means of access must be provided for all scaffolds.
h) Scaffold planking will extend over their end supports not less than 6 inches or more than 12 inches.
i) The use of shore or lean-to scaffolds is prohibited.
j) The poles, legs, or uprights of a scaffold must be be plumb and rigidly braced to prevent swaying and displacement.

k) Students in a lift will wear a safety harness attached to the lift per the manufacturer's recommendations.
l) When the lift is not in operation, the basket is to be raised out of access to the public and the key must be removed to prevent further use.
m) All appropriate PPE must be worn during activities performed on the scaffolding or lift.

9. Color Coding Systems

Color coding systems are to be used in an instructional space to indicate potentially hazardous areas within a laboratory.

Apply the following color-coding safety precautions as adopted from OSHA:

a) Red shall be used on fire protection equipment and apparatus, containers for flammable liquids, fire extinguishers, safety cans and safety signs, emergency stop bars, buttons, or electrical switches on hazardous machines.
b) Orange shall be used as the basic color for designating dangerous parts of machines or energized equipment that may shock, cut, crush, or injure. Orange shall be used to emphasize hazards when enclosure doors are open or when gear bolts or other guards around moving equipment are open or removed, exposing unguarded hazards.
c) Yellow shall be the basic color for designating caution and for marking physical hazards from falls, bumps, or collision. Yellow is also used to designate safety zones in aisles and around machines, handrails, low overhead areas, approaches to stairs, and floor areas around open pits. Solid yellow, yellow and black stripes, or checkers (or yellow with a suitable contrasting background) should be used interchangeably so the selected combination attracts the most attention.
d) Green and white shall be used to identify first aid equipment (other than firefighting equipment), safety equipment, and personal protective equipment storage areas.
e) Blue shall be the basic color for designation of caution, limited to warning against the starting, use of, or the movement of equipment under repair or being worked on.
f) Purple shall designate radiation hazards.
g) Black or white, or a combination of the two, shall be the basic colors for traffic and housekeeping markings.

C. Noise Control

Noise can destroy hearing, create physical and psychological stress, and contribute to accidents in addition to making it impossible to hear warning signals. CTE laboratories and shops are not exempt from noise pollution considerations, particularly if maximization of learning and safety are the goal.

Noise is an unwanted sound. It is a form of energy or vibration that is conducted through the atmosphere. There are four variables that can affect the intensity of noise and its potential danger.

1. The level of the sound, as measured in decibels (dB).
2. The length of time to which one is exposed to the sound.
3. The numbers and lengths of quiet (recovery) periods between periods of sound.
4. Individual sensitivity to or tolerance for sound.

NIOSH indicates that workers cannot be exposed to sound levels that exceed 85 decibels on average (dBA) for an eight-hour day. It should be noted that the standard applies only to work; day-to-day environments and schools are typically different. In some cases, however, CTE courses mimic industry and workplace environments and the standards therefore apply in those settings for safe learning. Furthermore, it should also be noted that instructor exposure throughout the workday is often the equivalent of industry even when student exposure during short class periods may not be. Since hearing is affected by the totality of the noise that one is exposed to, all precautions are appropriate.

Fortunately, noise exposure can be controlled. No matter what noise problems occur in the laboratory and workplace, there are technologies available to reduce noise hazards. The responsibility to correct noise problems rests on the individuals (e.g., supervisors, teachers, etc.), involved. In general, there are three basic ways to control noise.

1. Source Control

The best and most effective approach to control noise is to control it at the source to limit further hearing danger and the need for other methods. Techniques of noise source control include:

a) Reduction of impact noise.
b) Reduction of the speed of moving and rotating parts.

c) Reduction of pressures and flow velocities in circulating systems.
d) Reduction of flow resistance in circulation systems.
e) Balancing of rotating parts.
f) Reduction of friction in rotating, sliding, and moving parts.
g) Isolation of vibration within equipment.
h) Reduction of the size of the surface radiation areas.
i) Application of vibration-damping materials to vibrating parts and surfaces.

2. Path Control

If source control is not possible, the next best approach is to control the noise along its path. Although such controls limit the number of persons exposed to the noise, they do not always eliminate the noise problem for all persons affected. In path control, noise is blocked or reduced before it is heard. This can be accomplished by:

a) Containing or enclosing the noise.
b) Absorbing the noise along its path.
c) Deflecting the noise away from our ears.
d) Separating the noise from the listener.

3. Hearing Protection

Finally, ear protection equipment is available. This is not as desirable as either source or path control because it affords protection only to those wearing the equipment. Students must be wearing these hearing protectors whenever they are exposed to potentially dangerous noise. Certain conditions and activities can reduce the effectiveness of the hearing protectors themselves.

Cotton should not be used as protection against abrasive sound. While cotton balls may minimize waves of certain frequencies, it fails to alter the intensity thus providing a false sense of security. (See Appendix F for examples of hearing protection and hearing protection accessories.) Sound is measured by two fundamental characteristics: frequency (related to pitch) or number of waves per second, and intensity level (related to loudness). The human ear reacts to frequencies ranging from 20 cycles per second to about 20,000. Sound at a level of 85 decibels (dB) can lead to a loss of hearing, depending on (1) the intensity, (2) the frequency, (3) the duration of exposure, and (4) individual sensitivity.

Table 2 provides examples of noise and the approximate decibels for each.

Table 2: Approximate decibel level of example sounds.

Sound	Level (in decibels)
Average room noise	30-50 dB
Vacuum cleaner	70 dB
City traffic from inside of a car	85 dB
Motorcycle or subway	100 dB
Band saw	104 dB
Miter saw and impact wrench	109 dB
Jack hammer	130 dB
Jet engine from 100 yards away	135 dB
Fireworks	160 dB

Sources: *Hearing Health Foundation (2023) and Building Maintenance & Construction: Tools and Maintenance Tasks (2018) by University of Hawaii Maui College and the Construction Technology Program.*

D. OSHA Regulations

Occupational Safety & Health Administration Regulations (Standards 29 CFR), Part 1910 Occupational Safety and Health Standards should be taught and followed for these reasons:

- To protect students, staff, and guests from hazards in the simulated workplace of a CTE program.
- To teach the students industry standard safety procedures for future workplace success.

E. Construction

Occupational Safety & Health Administration Regulations (Standards 29 CFR), Part 1926 Safety and Health Standards for Construction programs should be followed.

F. Pressure Vessels

Students and instructors using boilers or pressure vessels should investigate and follow all procedures, standards, and recommendations of the American Society of Mechanical Engineers (ASME), using the current ASME Boiler and Pressure Vessel Code (BPVC).

G. Chemicals and Flammable Materials

See Chapter 3, General Instructional Guidelines.

H. Better Professional Safety Standards

Programs should follow the safety standards for their respective industry to best prepare students for post-secondary education programs and the workplace. For example, automotive technology programs should align instruction with the ASE Automobile Program Standards, which include safety information specific to this CTE pathway.

In addition, Safety Data Sheets (SDS) should be acquired, reviewed, kept on site, and followed for all applicable materials and/or products. See Chapter 3, General Instructional Guidelines.

References

Love, T. S., Roy, K. R., & Sirinides, P. (2023). A national study examining safety factors and training associated with STEM education and CTE laboratory accidents in the United States. Safety Science, 160(106058), 1-13. https://doi.org/10.1016/j.ssci.2022.106058

CHAPTER 8:

Family & Consumer Science and Culinary Arts Guidelines

Chapter 8: Family & Consumer Science and Culinary Arts Guidelines

In addition to food and kitchen facilities, family and consumer science (FACS) and culinary arts programs may include areas for serving meals to provide students with a well-rounded experience. These areas must be near, but separate from, the kitchen or food preparation facility. All facilities must prepare students to meet national and state level code(s) and sanitation regulations regarding the preparation and serving of food.

FACS programs may also offer courses on textile technologies, human development and early childhood education, life skills for young adults, and other emerging topics.

A. Safety Guidelines and Required Student Safety Training

1. Students should be knowledgeable about fire safety in the kitchen. This includes pot fires, range top fires, the fire suppression system in a kitchen, burns, safely moving hot items, heat transfer to metal tables, and room evacuation plans.
2. Students should be taught appropriate hand washing skills, housekeeping/clean up skills, and how to avoid cross-contamination.
3. Students should also be properly trained and supervised on safer practices for the use of sharp items used in FACS and culinary arts programs. This could range from knives for cooking to needles and shearers for textile projects. Students should be trained to carry sharp objects point down at their side and to cut away from their fingers or body. Students should also be trained to not catch sharp items — if a sharp item is dropped, let it fall.
4. The proper cleaning, use, and storage of all sharp items should be demonstrated to students.
5. Students should also be trained on the handling of all equipment before use. Equipment in a FACS laboratory could include items like a stove, heat press/iron, mixer, sewing machine, and other items. Manufacturers' operating procedures and maintenance procedures

should be followed for all machines and equipment in FACS and culinary arts learning areas.

6. Safety signage, safety zones, and established communication systems for signifying when items are still hot or in use should be used (See Chapter 3, General Instructional Guidelines).

B. Facilities

Adequate space is an essential component of safety for every program. Space allocations will differ depending on the type of program and the students involved. Table 3 contains some general guidelines for spaces in FACS and culinary arts programs. When possible, they should be followed to ensure adequate space.

Table 3: Space allocations for example classrooms

Classroom	25 square feet per student
Kitchen facility	150 square feet per student
Textiles facility	60 square feet per student
Early childhood classroom (non-laboratory activities)	25 square feet per student
Storage	400 square feet

The number of students in the classroom should be kept to a reasonable limit, as close to 20 students as possible. Keeping the class size small promotes safety as well as adequate supervision and instruction for all students.

The facility must be designed so that the instructor always has full view of the entire facility (e.g., avoiding blind spots). It is important that appropriate utilities be in place, including plenty of lighting, hot and cold water, and adequate GFI protected electrical outlets and other outlets with the correct voltage for the equipment used throughout the kitchen stations. Extension cords should be avoided, as they can create trip/fall hazards, fire hazards, and electrical hazards in labs.

Facilities should also be designed to accommodate the needs of students with varying abilities. Adequate ventilation must be provided in these areas, including range exhaust hoods and appropriate hourly room exchanges of filtered air to address particulates and gases produced during food preparation. Air filters need to be on a calendar replacement program schedule, approximately 4 or more times per year.

Traffic Patterns in the Instructional Area

1. As students and instructors are moving hot items or needing space to measure fabric, they will be at a higher risk for burns, cuts, and other potentially avoidable accidents without a correct flow for movement (See Chapter 1, Responsibilities in Instructional Spaces).
2. Tools, equipment, and machines must be secure to prevent injury, and should not be operated without an instructor present.

C. Engineering Controls

1. The type of fire extinguishers required will depend on the types of activities being conducted in that area. Grease fires cannot be extinguished with a standard ABC type extinguisher.
2. Extinguishers with a K rating are designed to extinguish fires involving vegetable oils, animal oils, or fats used in commercial cooking appliances. Only the class K fire extinguisher is compatible with these wet chemical agents. The use of a multipurpose ABC extinguisher threatens the foamy layer and cooling ability of the wet chemical agent and consequently can result in damage to cooking appliances.
3. All building codes for fire suppression systems should be followed.
4. Externally vented exhaust hoods are required for different activities.
5. Master power, water, and gas shutoff switches/valves should be easily accessible to teachers and students in the event of an emergency.

D. Student Dress

Student dress is critical for safer and more sanitary operations. Proper dress includes:

1. Flat heels, closed-toe non-slip shoes are to be worn by staff and students.
2. Baggy, extra-long sleeves, or fur-trimmed clothing (including sports jerseys, sweatshirts, or hoodies) are to be removed.
3. Long pants must be worn by staff and students working in kitchen and food service laboratory settings.
4. Hair must be restrained on top of the head or at the nape of the neck. When working in kitchen and serving areas, a hat or hairnet must be worn.
5. In the case of head coverings for religious purposes, a hairnet must be worn to contain the long parts of the head covering.
6. Aprons or chef's coats must be worn when working in kitchen and food service laboratory settings.

E. Storage

1. It is important to have adequate storage for perishable, frozen, and non-perishable foods, which must be labeled with a date.
2. Lockable storage for knives and sharp equipment should be included, as well as lockable storage for expensive items.
3. Knives should be sanitized and stored security.
4. Materials used in family and consumer sciences must adhere to Department of Public Health Food Code and the ServSafe guidelines for chemical storage. Household chemicals should be used only in accordance with manufacturer's instructions.

F. Housekeeping and Disposal

1. Countertops, dishes/silverware, and sinks should be cleaned with appropriate sanitary solutions at the end of each class.
2. Sinks should remain clear during lab activities to avoid splashing hot water when straining or draining items.

3. All spills should be cleaned up immediately unless they involve hot water or chemicals. In these cases, students should notify the instructor immediately for guidance on using the appropriate cleanup methods, following all criteria specified in the SDS, or contact the school district's safety officer and/or Chemical Safety Officer.
4. Instructors should conduct weekly audits of food in refrigerators and maintain an inventory with expiration dates. It is important to clean out refrigerators and cabinets of any items that will expire before leaving for extended breaks.
5. Instructors should work with their school district's custodial staff to notify them of food-related trash or sharp items that need to be removed to protect the custodial staff, teacher, and students.

CHAPTER 9:
Health Sciences Guidelines

Chapter 9: Health Sciences Guidelines

In the classroom setting, instructors should follow the general school/program safety protocols described below. Safety in clinical settings may vary based on the policies of the clinical employer.

A. General Safety Practices in the Instructional Space

1. Only use purchased, sterilized, or artificial body fluids for teaching/learning purposes.
2. Teach proper hand hygiene in the instructional setting:
    a) Wet hands with clean, running water (warm or cold) and apply soap.
    b) Rub hands together to make a lather and scrub well; be sure to scrub the backs of the hands, between fingers, and under nails.
    c) Continue rubbing hands for at least 20 seconds.
    d) Rinse hands well under running warm water.
    e) Dry hands using a clean towel or air dryer.

    Washing hands with soap and water is the best way to reduce the number of germs on them. If soap and water are not available, use an alcohol-based hand sanitizer that contains at least 60% alcohol. Alcohol-based hand sanitizers can quickly reduce the number of germs on hands in some situations, but sanitizers do **not** eliminate all types of germs. Hand sanitizers are **not** effective when hands are visibly dirty.
    Proper use of hand sanitizers:

    - Apply the product to the palm of one hand.
    - Rub hands together.
    - Rub the product over all surfaces of hands and fingers until hands are dry.

3. Ensure work surfaces and equipment are decontaminated as soon as possible after specimens are processed.
4. Ensure infectious waste (biohazardous waste), including sharps, are collected in proper containers. Infectious waste must be segregated and put through a decontamination process before it is considered safer for routine handling as solid waste. For this reason, infectious waste should be collected in special containers.

a) Sharps containers should be durable, closable, leak resistant on their sides and bottoms, and puncture resistant until final disposal. A sufficient number of sharps disposal containers should be provided. Individual containers should have adequate volume and safe access to the disposal opening.
b) Containers should be accessible to students who use, maintain, or dispose of sharp devices. Containers should be conveniently placed and (if necessary) portable within the instructional space.
c) Containers should be plainly visible with proper warning labels and color coding.
d) Laboratory waste, such as bacterial cultures and any discarded contaminated items, should be disposed of in proper containers using medical waste disposal services that provide regulatory compliance for biohazardous materials.

B. General Safety Practice in Clinical Instructional Spaces

1. **Immunization/PPD**
   a) All healthcare professionals, including students and volunteers, should receive annual immunizations.
   b) Students should receive baseline Tuberculosis (TB) screening using a skin test before participating in a clinical experience at a healthcare facility. After baseline testing for TB infection, additional TB screening is not necessary unless an exposure to tuberculosis occurs.

   Students with a baseline or newly positive tuberculosis test should have a chest radiograph to rule out TB disease. Repeat radiographs are only necessary if symptoms develop or a clinician recommends them.

   For more information, see Guidelines for Preventing the Transmission of Mycobacterium tuberculosis in Healthcare Settings (2005).

2. **Personal Protective Equipment (PPE)**
   Healthcare workers can be protected by personal protective equipment (PPE) against exposure to bloodborne pathogens, such as hepatitis B virus (HBV), hepatitis C virus (HCV), and human immunodeficiency virus (HIV). Wearing appropriate PPE can significantly reduce risk, since it acts as a barrier against exposure.

   Personal protective equipment may include:

   - non-latex gloves
   - gowns
   - laboratory coats
   - face shields or masks
   - eye protection (e.g., indirectly vented chemical splash goggles)

   For more detailed information about the use of PPE, refer to the Occupational Safety and Health Administration (OSHA) fact sheet on PPE and exposure to bloodborne pathogens.

3. **Latex Exposure/Allergies**
   Latex gloves have proved effective in preventing transmission of many infectious diseases. However, latex allergies are among the most common workplace hazards in dentistry and other healthcare services, as it can cause a range of allergic reactions, from irritable rashes to anaphylaxis. Therefore, non-latex gloves should be used in classroom and clinical settings.

4. **Safer Lifting Practices/Body Mechanics**
   Safe resident lifting programs are highly effective in reducing a healthcare worker's exposure to heavy loads and awkward working postures that contribute to back and musculoskeletal injuries.

   The following are fundamentally safe lifting guidelines intended to be used to prevent injury.
   a) Manual lifting should not be permitted except in life-threatening circumstances.
   b) Keep lifting equipment readily available and accessible. The number of lifts required will depend on the level of physical dependency among the residents.

c) Be certain that backup battery packs are available so lifts can be used 24 hours per day.
d) Sufficient slings of the proper size should be available.
e) Equipment should be stored in a convenient location.
f) The lifting needs of each resident should be assessed and reassessed as their transferring needs change.

For more information, refer to the CDC/NIOSH policy/recommendations for safer lifting of nursing home patients.

5**. Sharp Injuries**

A sharp injury is a penetrating stab wound from a needle, scalpel, or other sharp object that may result in exposure to blood or body fluids.

a) Prevention:
- Eliminate or reduce the use of needles and other sharps.
- Use devices with safety features to isolate sharps.
- Use safe practices to minimize risk for hazards.

b) Following a sharp injury:
- Provide immediate care to the exposure site.
- Wash wounds and skin with soap and water.
- Flush mucous membranes with warm water.
- Notify your clinical instructor or facility supervisor and make certain that the facility policy is implemented.
- Have a qualified practitioner evaluate the exposure to determine the risk associated with exposure.
- Receive post-exposure prophylaxis (PEP) for exposures posing risk of infection transmission.

For additional information on sharps safety in healthcare settings, please visit the CDC's Sharp Safety Program Resources.

CHAPTER 10:
Technology and Engineering Education Guidelines

Chapter 10: Technology and Engineering Education Guidelines

Personal protective instructional space (laboratory practices), environmental concerns, and equipment considerations refer to the procedures, practices, and equipment recommended by laboratory health and safety experts. These guidelines align with legal safety standards and best professional practices to effectively minimize individual exposure to safety hazards and associated risks.

A. Personal Protective Instructional Space Practices

Personal protective instructional space practices include:

a) Wear eye protection as required by Delaware law whenever the process used can cause damage to the eyes or the protective device can reduce the risk of injury. The use of indirectly vented chemical splash safety goggles, safety glasses with side shields, or other eye protection is required when there is a danger of eye injury in the instructional space.
b) Confine long hair so that it is not exposed to machinery and does not interfere with vision. Secure or remove loose clothing and remove jewelry and accessories that may get caught in a machine.
c) Always wear proper footwear. No open-toed shoes, flip-flops, or sandals.
d) Wear respirators when harmful dust or fumes exist. Respirator use requires appropriate certification, fit testing, and supervision to ensure that proper fit, training, and inspection all take place.
e) Determine the physical limitations of all students so that they will not be assigned tasks detrimental to their health or physical condition. Work with your special education department to make required accommodations or modifications that do not impede the safety of the student or others in the facility.
f) Wear ear protection when noise levels are excessive over long periods of time. Ensure that protective apparel, including safety shoes, aprons, shields, and non-latex gloves are worn properly as required by the nature of the task.

g) Make provisions for the cleaning and sterilizing of respirators, masks, and goggles/glasses.
h) Ensure that head protection is worn in all areas where there is danger of falling and/or flying objects. Ensure students check with the instructor before performing any tool, machine, material, or chemical operations.
i) Keep the work area clear of scrap materials.
j) Do not clean up metal or sharp scraps by hand or with an air compressor. Use a brush and dustpan.
k) Set up the machine for the specific operation and inspect it before use.
l) Properly position all safety guards.
m) Ensure that students focus full attention on the machine operation.
n) Make machine or stock adjustments only after the machine has fully stopped motion and is turned off.
o) If a problem occurs, stop the machine at a safe point.
p) Ensure that a machine is never left unattended and running.
q) Remove scrap material that has accumulated after operation and/or when the machine is not running.

B. Environmental Considerations

The environmental considerations are the elements in an instructional space setting where safeguards and safety procedures need to be in place for students, teachers, and any visitors in the facility. The laboratory is an instructional space where materials are processed to produce products or prototypes. Laboratories also may use hazardous chemicals on occasion for educational purposes. The following environmental considerations shall be applied toward laboratory instructional space environments.

1. Facility Size

The size, shape, and arrangement of a facility as well as the location of passageways, storage, and work areas are important factors in establishing a safer working environment. The number of students that can be safely placed into the instructional program may vary with the program requirements and activities. Some programs that involve moving long materials that will be cut and shaped for prototyping activities may require

more room per student. Other programs where the students are seated rather than being involved with material processing activities may require less space. In general, if the number of students placed in the instructional space is greater than the recommended area, the potential for accidents will increase. NPFA specific occupancy load standards apply in laboratory spaces.

The International Technology and Engineering Educators Association (ITEEA, 2010) recommends 180 square feet per student for contemporary technology and engineering education laboratories with instructional areas for design, prototyping, fabrication, automation, presentation, office space, and storage (The Delaware minimum is 50 square feet per person).

To estimate the amount of space needed for a contemporary laboratory, determine the number of students per class and multiply by the recommended square feet. Then add 10 to 20% additional space for storage. EXAMPLE: 20 students x 180 sq ft = 3,600 sq. ft. + 15% storage = an additional 540 sq ft. Total = 4,140 sq ft.

2. Hearing Protection

Ear protection is required while operating machines. Cotton should not be used as protection against abrasive sound. While cotton balls may minimize waves of certain frequencies, it fails to alter the intensity, thus providing a false sense of security.

Sound is measured by two fundamental characteristics: frequency (related to pitch) or number of waves per second, and intensity level (related to loudness). The human ear reacts to frequencies ranging from 20 cycles per second to about 20,000. Sound at a level of 85 decibels (dB) can lead to a loss of hearing depending on (1) the intensity, (2) the frequency, (3) the duration of exposure, and (4) individual sensitivity. The following are examples of noises and the approximate decibels for each.

Table 2 provides examples of noise and the approximate decibels for each.

Table 2: Approximate decibel level of example sounds.

Sound	Level (in decibels)
Average room noise	30-50 dB
Vacuum cleaner	70 dB
City traffic from inside of a car	85 dB
Motorcycle or subway	100 dB
Band saw	104 dB
Miter saw and impact wrench	109 dB
Jack hammer	130 dB
Jet engine from 100 yards away	135 dB
Fireworks	160 dB

Sources: *Hearing Health Foundation (2023) and Building Maintenance & Construction: Tools and Maintenance Tasks (2018) by University of Hawaii Maui College and the Construction Technology Program.*

Laboratory instructional space equipment and activities may produce noise levels requiring the use of hearing protection. The OSHA Occupational Noise Standard (29 CFR 1910.95) has established a noise action level of 85 decibels (dBA) averaged over eight hours. Wind tunnels, motors, engines, tools / equipment, and other laboratory instructional space equipment used in laboratories have the potential to exceed the action level. Teachers must monitor sound levels and provide hearing protection for themselves and students. It is advised that this safety practice be applied even below the action level. (See Appendix F for examples of hearing protection and hearing protection accessories.)

3. Lighting

A well-lit laboratory instructional space includes both natural and artificial lighting.

- In general, a 5:1 ratio of floor space to window area is recommended for natural lighting.
- Artificial lighting should provide a minimum of 50-to-100-foot candles. In laboratories where detailed work is done, up to 200-foot candles are recommended.
- A uniform color scheme should be used in the laboratory instructional space. Walls should reflect about 60 to 70% of the light that strikes them.

4. Safety Zones

In a laboratory instructional space, safety zones are established to isolate areas and to provide safer traffic lanes for the students to move through the space.

Apply the following safety precautions:

- Major aisles should be 4 feet wide.
- Other traffic lanes should be 3 feet wide.
- A minimum of 3 feet on each side of stationary power machines is recommended.
- Laboratories should be arranged by activities involved.
- Paint, welding, machining, and foundry should be isolated from each other.
- Machines that exceed 4 feet in height should be placed in close proximity to walls.
- Attention should be given to the direction of chip throw and kickback. These danger zones should be marked.

More information about safety zones can be found at NSTA's STEM Lab Safety Zones for Hazardous Areas.

5. Instructional Space Ventilation

Ventilation in an instructional space is critical for safer and healthy operation. Little or no ventilation can allow the buildup of explosive or flammable vapors, cause respiratory symptoms, and more.

Apply the following safety precautions:

a) Occupied lab air exchange rates should be 6 to 10 times an hour based on the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE) handbook, or greater than 8 air exchanges per NFPA 45. Contact your school facilities director to have the air exchange rate assessed.
b) Unoccupied lab air exchange rates, including chemical storerooms, should be 4 times an hour per NFPA 45.
c) Air supplies to labs, storerooms, and preparation rooms should never be recycled to any other part of the building, including other labs, classrooms, and offices.
d) Only conduct experiments that the ventilation system can manage. Otherwise, use a fume hood or select an alternate experiment. Limit occupant exposure.
e) Preventative maintenance programs should be in place to change ventilation filters about 4 times a year. Filters need to be changed on a quarterly basis.
f) Equipment that may produce a large quantity of dust should have a properly installed dust collection system to reduce the risk of combustible dust. The NFPA and OSHA standards require separate dust collection systems for machines producing wood dust, metal dust, and aluminum dust, each at the source of the dust production.
g) Laser engravers should always be properly vented with an approved interior air filtration system or externally vented in collaboration with your district's maintenance department.

Years of research have found various types of 3D printers emit volatile particles that can be breathed in. The type of material can dictate the number of particles. Better professional practice recommends an air change rate of at least 4 times per hour for PLA and ABS printers. Other types of printers may require direct ventilation. Please follow all manufacturer recommendations. A good resource for instructional space ventilation is NFPA 45. It addresses required forced air ventilation in science laboratories, including academic labs, and other instructional areas. For more information, see DeLabCon's "A Guide to Fume Hood Codes and Standards".

6. Security

To support instruction and protect the instructional space from theft, misuse, etc., the following safety precautions should be applied:

a) A shadow board or tool organization panel, where silhouetted tools are labeled/numbered so that missing items can be easily determined.
b) Supply cabinets are organized so that items have a clearly marked placement. The cabinets should be able to be locked by the instructor to protect contents.
c) Large equipment has lockable/keyed switches to prevent use without the permission of the instructor.
d) Computer security policies are established and enforced. Review local district and school policies to ensure compliance and effectiveness.

7. Recordkeeping

a) Always keep an accurate record of accidents for records and report through proper channels in your district.
b) Conduct an analysis of accidents for the purpose of corrective action.

8. First Aid

Teachers must immediately report any injury occurring in a laboratory instructional space, no matter how minor, to the school nurse and administration. Teachers are strictly prohibited from administering any medication, including topical agents or cough drops, to students.

If a student is seriously injured and cannot be moved, the teacher must call for the nurse and ensure the area around the student remains clear. Teachers should generally not administer first aid unless the student's life is in immediate danger, which includes applying adhesive bandages for cuts. All first aid and medical treatment must be handled by the school nurse.

Teachers should not leave the injured student unattended. Instead, they should send another student to use the classroom phone or seek assistance from another teacher or the school nurse. Refer to local district and school policies for further guidance.

a) First aid kits that are OSHA compliant, sanitary, and properly stocked should be accessible in each instructional space laboratory, along with a written phone number for the school nurse's office for medical support in case of an incident.
b) Check with local district or school policies on employees administrating first aid.
c) Teachers and students must be aware of trained personnel in the school and the location of the nearest emergency medical treatment location.
d) Protective gloves must be worn when first aid requires immediate treatment and bodily fluids are present.
e) Eye wash stations and showers must be regularly checked for proper operation. (See Chapter 2, Principles of Safety Practices.)
f) Follow OSHA eyewash station maintenance and inspection requirements:
    i. Activate plumbed units at least weekly to verify proper operation.
    ii. Visually check self-contained units weekly to determine if flushing fluid needs to be changed or supplemented.
    iii. Inspect annually for compliance with ANSI/ISEA Z358.1 performance requirements.

9. Facility Condition

a) Aisles, machines, benches, and other equipment are arranged to conform to good safety practices.
b) Follow all ADA requirements and building codes for aisles and accessibility. Typically, this requires a minimum of a 3 foot clearance for facilities, including storage spaces.
c) Stairways, aisles, and floors are maintained, clean, dry, and unobstructed, with no protruding objects.
d) Walls, windows, and ceilings are clean, maintained in good repair, and free of protrusions.
e) Illumination is safe, sufficient, and well placed.
f) Ventilation and temperature controls are proper for conditions.
g) Fire extinguishers and other necessary fire equipment are properly selected, adequately supplied, properly located, and inspected and periodically recharged as required.
h) Exits are properly identified and illuminated (minimum of 2 egress exits per 1,000 square feet).

i) Lockers and drawers are clean, free of hazards, and doors kept closed.
j) Staff and students know the procedures for notification of fire and evacuation of premises.
k) Instructional spaces, laboratories, and workplaces are free from excessive dust, smoke, and airborne toxic materials.
l) Ensure ventilation is not recycling hazards back into the building.
m) Separate dust collectors may be needed for different types of combustible materials (e.g., metal vs. wood vs. aluminum dust).
n) Utility lines and shutoffs are properly identified and easily accessible.
o) Stairways, floor openings, and overhead storage areas are properly guarded with rails and toe boards and have the proper clearances.

10. Color Coding Systems

Color coding systems are used in an instructional space to indicate both safer and potentially hazardous areas.

Apply the following color-coding safety precautions as adapted from OSHA:

a) Red shall be used on fire protection equipment and apparatus, containers for flammable liquids, fire extinguishers, safety cans and safety signs, emergency stop bars, buttons, or electrical switches on hazardous machines.
b) Orange shall be used as the basic color for designating dangerous parts of machines or energized equipment that may shock, cut, crush, or injure.
c) Orange shall be used to emphasize hazards when enclosure doors are open or when gear bolts or other guards around moving equipment are open or removed, exposing unguarded hazards.
d) Yellow shall be the basic color for designating caution and for marking physical hazards from falls, bumps, or collision. Yellow is also used to designate safety zones in aisles and around machines, handrails, low overhead areas, approaches to stairs, and floor areas around open pits. Solid yellow, yellow, and black stripes, or checkers (or yellow with suitable contrasting background) should be used interchangeably so that the selected combination will attract the most attention.

e) Green and white shall be used to identify first aid equipment (other than firefighting equipment), safety equipment, and personal protective equipment storage areas.
f) Blue shall be the basic color for designation of caution, limited to warning against the starting, use of, or the movement of equipment under repair or being worked upon.
g) Purple shall designate radiation hazards.
h) Black or white, or a combination of the two, shall be the basic colors for designation of traffic and housekeeping markings.

11. Housekeeping Practices and Considerations

a) Provide for the storage and daily removal of all sawdust, metal cuttings, rags, and other waste materials.
b) Provide properly marked boxes, bins, or containers for various kinds of scrap stock and rags.
c) Rags with paint/chemicals should be disposed of in a combustible trash container and removed from the instructional site to the outside at the end of each day.
d) When disposing of sharp materials like knife or saw blades, notify custodial staff so they do not injure themselves when taking out the trash.
e) Use sturdy racks and bins for material storage, arranged to keep material from falling on students and to avoid injuries from protruding objects. Heavier and larger items should be stored on the bottom.
f) Employ a standard procedure to keep floors free of oil, water, and foreign material.
g) Provide for the cleaning of equipment and facilities after each use.
h) Provide regular custodial service in addition to end of class cleanup.
i) Prohibit the use of compressed air to clean clothing, equipment, and work areas.
j) Keep walkways and work areas free of all obstructions.
k) Floor surfaces must be maintained in a “nonskid” condition. Nonskid strips are significantly associated with lower accident occurrences (Love et al., 2023).
l) Tools and materials are stored orderly and safely.
m) File cabinets and other tall cabinets are required to be anchored.

12. Tool and Powered Equipment Considerations

Injuries in instructional spaces can occur with the improper use of tools and equipment. Training and supervision are essential for the safer use of tools and equipment. The following considerations should be applied toward tools and equipment.

Power equipment and machines

a) All equipment should be operated in accordance with specifications as stated in the owner's manual.
b) All students should have knowledge of operation procedures for each tool or machine to prepare, operate, and terminate a procedure.
c) Each student must have the appropriate motor skills needed to perform a tool or machine operation safely.
d) Machines and apparatus are arranged so that operators are protected from hazards of other machines or passing individuals. Guards are the ones approved by the manufacturer and in good working condition.
e) Point of operation zones are properly identified and guarded.
f) Permanent enclosure guards properly protect pulleys, gears, and belts.
g) Guards are removed only for repair purposes and then replaced immediately.
h) Equipment control switches for each machine are easily available to the operator.
i) Machines are turned off when the instructor is out of the room and/or if the machine is unattended. Proper cleaning equipment is used (avoid air for cleaning purposes). Nonskid areas are maintained around dangerous equipment.
j) A preventive maintenance program is established for all equipment.
k) Cutting tools are kept sharp, clean, and in safe working order.
l) All hoisting devices are maintained in a safe operating condition and specified load ratings are easily identified.
m) Machines that are defective or being repaired are clearly marked and made inoperable by locking out the machine power switch.
n) Machines and apparatus are marked with the proper color codes, as outlined previously in this chapter.
o) Equipment cords and adapters are maintained in a safe working condition.

p) Adjustment and repair of any machine is restricted to experienced persons.
q) Ladders are maintained and stored properly — anchored to a wall.
r) Machines designated for fixed location are securely anchored.
s) The appropriate personal protective equipment selected to be worn must at minimum match the specification for protection for the tool, equipment, or task.

Hand Tools

a) Use the signage and acknowledgement form available at ITEEA's Safety Resources.
b) Copy and paste guidelines from the ITEEA poster available at the link above.
c) Instruct students to select the right tools for each job.
d) Establish regular tool inspection procedures to ensure tools are maintained in safer condition.
e) Instruct students in the correct use of tools for each job.
f) Provide proper storage facilities.
g) Do not place tools on operating machinery or equipment.
h) Keep tools out of aisles and working spaces where they may become tripping hazards.
i) Do not put sharp objects or tools in pockets. This could result in cuts or being stabbed.

For additional tool and machine resources, please see the ITEEA website.

Appendices

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Appendix A: Regulation 885 — Safe Management, Storage, and Disposal of Chemicals in the Delaware Public School System

885 Safe Management and Disposal of Chemicals

1.0 Purpose

The purpose of this regulation is to outline the criteria and processes for chemical storage and use in the classroom, laboratory, or other instructional areas. This regulation sets forth the requirements for the safe procurement, management, storage, and disposal of chemicals. Additional information may be found in the *Safety First: Safe Instructional Practices in the Classroom and Laboratory* manual.

20 DE Reg. 975 (06/01/17)

26 DE Reg. 51 (07/01/22)

2.0 Definitions:

The following words and terms, when used in this regulation, shall have the following meaning unless the context clearly states otherwise:

“Carcinogen” means any known or suspected chemical that can cause cancer.

“Chemical” means any element, compound, or mixture of elements or compounds.

"Chemical Inventory" means a list of all materials and chemicals for which a Safety Data Sheet or "SDS" must be maintained.

“Chemical Name” means the scientific designation of a chemical in accordance with the nomenclature system developed by the International Union of Pure and Applied Chemistry or "IUPAC" or the Chemical Abstracts Service or "CAS" rules of nomenclature, or a name which will clearly identify the chemical for the purpose of conducting a hazard analysis.

"Chemical Procurement" means the acquisition of any chemicals.

“Common Name” means any designation or identification such as a code name, code number, trade name, brand name, or generic name used to identify a chemical other than its chemical name.

“Corrosive” means causing visible destruction of or irreversible alterations in living tissue by chemical action at the site of contact.

"Department" means the Delaware Department of Education.

"Engineering Control" means a physical modification to a process, or process equipment, or the installation of further equipment with the goal of preventing the release of contaminants and improve safety conditions.

“Explosive” means causing a sudden, almost instantaneous release of pressure, gas, and heat when subjected to sudden shock, pressure, or high temperature.

“Expose” or "Exposure" means an instance where an individual is subjected to or potentially subjected to a hazardous chemical through any route of entry (inhalation, ingestion, skin contact or absorption, etc.).

“Hazardous Chemical” means any element, compound or mixture of elements which presents a physical hazard or health hazard.

“Health Hazard” means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed persons. The term "Health Hazard" includes chemicals which are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents which act on the hematopoietic system, and agents which damage the lungs, skin, eyes, or mucous membranes. The Safety Data Sheet or "SDS" will provide information to determine whether or not the chemical is a health hazard.

“Instructional Area” means a room or defined space used for an educational activity such as a classroom, a laboratory, a field, a special building, greenhouse, or any other space where educational activities may take place.

“Long-Term Storage” means the storage of any chemical for a time period past the end of the school day.

“Non-hazardous Chemical” means any element, compound or mixture of elements or compounds which do not present a physical hazard or health hazard as indicated by the Safety Data Sheet.

“Occupational Safety and Health Administration” or "OSHA" means the government agency which is part of the United States Department of Labor that develops guidelines to maintain a healthy and safe working environment.

"Personal Protective Equipment" or "PPE" means equipment worn to minimize exposure to hazards that cause serious injuries and illnesses. These injuries and illnesses may result from contact with chemical, radiological, physical, electrical, mechanical, or other hazards. Personal protective equipment may include, but is not limited to, items such as gloves, safety glasses and shoes, earplugs or muffs, hard hats, respirators, or coveralls, vests and full body suits.

“Physical Hazard” means a chemical which is identified by the Safety Data Sheet as a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer, pyrophoric, unstable (reactive) or water reactive.

“Safety Data Sheet” or "SDS" means a document that contains information on the potential health effects of exposure to chemicals, or other potentially dangerous substances, and on safe working procedures when handling chemical products. It contains hazard evaluations on the use, storage, handling and emergency procedures related to that material. The Safety Data Sheet contains more information about the material than the label and is prepared by the supplier. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure, and what to do if such incidents occur.

"Safety First: Safe Instructional Practices in the Classroom and Laboratory Manual" means the collection of documents that outline the mandatory safety procedures regarding the safe management, storage, and disposal of chemicals for instructional areas in Delaware public schools and which may be amended from time to time as published in the *Delaware Register of Regulations*. The manual also provides safety practices that are governed by this regulation. This document is available on Digital DE.

"Short-Term Storage" means the storage of any chemical for a time period before the end of the school day.

"Storage" means a space for the containment of chemicals or other materials.

"Surplus Chemical" means any chemical that is no longer useable or needed.

"Useable" means that the chemical or other material has not surpassed its expiration date.

20 DE Reg. 975 (06/01/17)

26 DE Reg. 51 (07/01/22)

Appendix B: Glossary of Terms

For educators to work successfully in the safety arena, they must understand how definitions apply to the laboratory and/or any other instructional spaces. OSHA definitions are commonly accepted as legal definitions and help to foster understanding of standard operating procedures. This in turn helps teachers plan better and work toward securing and maintaining a safer work environment in the laboratory for all occupants.

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

Biological hazards are organisms, or substances produced by organisms, which pose a threat to human or animal health.

Carcinogen means any chemical that can cause cancer. Included are known or suspected carcinogens such as formaldehyde, benzene, carbon tetrachloride, nickel salts, sodium dichromate and sodium chromate.

Chemical means any element, compound, or mixture of elements and/or compounds.

Chemical hazard is any substance, regardless of its form, that can potentially cause physical and health hazards to people or service animals or can result in harm to the environment. This can include paints, solvents, fuels, and other forms of chemical-based items commonly found in science, technology, and engineering, and CTE laboratories.

Chemical Name means the scientific designation of a chemical in accordance with the nomenclature system developed by the International Union of Pure and Applied Chemistry (IUPAC) or the Chemical Abstracts Service (CAS) rules of nomenclature, or a name which will clearly identify the chemical for the purpose of conducting a hazard evaluation.

Chemical Safety (Hygiene) Officer means an employee who the local district or school designates, and who is qualified by training or experience, to provide technical guidance in the development and implementation of the provisions of the chemical safety plan.

Chemical Safety Plan means a written program developed and implemented by the local district or school that sets forth specific procedures, personal protective equipment and work practices that can protect students and school employees from the health hazards presented by hazardous chemicals.

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

Common Name means any designation or identification such as a code name, code number, trade name, brand name, or generic name used to identify a chemical other than its chemical name.

Compressed gas means:

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

Corrosive means a chemical that causes visible destruction of or irreversible alterations in, living tissue by chemical action at the site of contact.

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

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

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

Expose or Exposure means an instance where an individual is subjected to a hazardous chemical through any route of entry (inhalation, ingestion, skin contact or absorption, etc.) and includes potential (e.g., accidental, or possible) exposure.

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

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

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

Hazardous Chemical means any chemical that presents a physical hazard or health hazard.

Health Hazard means a chemical for which there is statistically significant evidence based on at least one study conducted in accordance with established scientific principles that acute or chronic health effects may occur in exposed employees. The term "health hazard" includes chemicals that are carcinogens, toxic or highly toxic agents, reproductive toxins, irritants, corrosives, sensitizers, hepatotoxins, nephrotoxins, neurotoxins, agents that act on the hematopoietic systems, and agents that damage the lungs, skin, eyes, or mucous membranes. The material safety data sheet (MSDS) will provide information to determine whether or not the chemical is a physical hazard.

Instructional Space means a room or defined space used for an educational activity. An instructional space may be a classroom, a laboratory, a makerspace, a field, a special building such as a greenhouse, or any other space where educational activities may take place.

Laboratory means an instructional space where the "laboratory use of hazardous chemicals" occurs in an educational environment. It is a workplace where relatively small quantities of hazardous chemicals are used on a nonproduction basis for educational purposes.

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

Laboratory-type hood means a device located in a laboratory, typically with an enclosure on five sides with a movable sash or fixed partial enclosed on the remaining side; constructed and maintained to draw air from the laboratory and to prevent or minimize the escape of air contaminants into the laboratory; and allows chemical manipulations to be conducted in the enclosure without insertion of any portion of the employee's body other than hands and arms. See also ***Fume Hood*** in Chapter 3, General Instructional Guidelines.

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

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

Long-Term Storage means the storage of any chemical for a time period past the end of the school day.

Safety Data Sheet (SDS) A Safety Data Sheet (formerly called Material Safety Data Sheet or MSDS) is a detailed informational document prepared by the manufacturer or importer of a hazardous chemical. It describes the physical and chemical properties of the product. It contains hazard evaluations on the use, storage, handling, and emergency procedures related to that material. The SDS contains much more information about the material than the label and it is prepared by the supplier. It is intended to tell what the hazards of the product are, how to use the product safely, what to expect if the recommendations are not followed, what to do if accidents occur, how to recognize symptoms of overexposure, and what to do if such incidents occur.

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

Mutagen means chemicals that cause permanent changes in the amount or structure of the genetic material in a cell. Chemicals classified as mutagens in accordance with the Hazard Communication Standard (§ 1910.1200) shall be considered mutagens for purposes of this section.

Non-hazardous Chemical means any element, compound, or mixture of elements and/or compounds which do not present a physical hazard or health hazard.

Occupational Safety and Health Administration (OSHA) means the government agency in the Department of Labor that develops guidelines to maintain a healthy and safe working environment.

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

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

Physical hazard means a chemical for which there is scientifically valid evidence that it is a combustible liquid, a compressed gas, explosive, flammable, an organic peroxide, an oxidizer pyrophoric, unstable (reactive) or water reactive. The safety data sheet (SDS) will provide information to determine whether or not the chemical is a physical hazard. Physical hazards can also appear in the form of projectiles or other items that may be present in laboratories.

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

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

Short-Term Storage means the storage of any chemical for a time period before the end of the school day.

Storage means a space for the containment of chemicals or other materials.

Surplus Chemical means any chemical that is no longer useable or needed.

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

Useable means that the chemical or other material has not surpassed its expiration date.

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

Appendix C: On-Site Compliance Monitoring Checklists

Prior to submitting a new demonstration/activity/laboratory/field investigation for approval, the following must be completed:

- Safety training
- Safety Acknowledgment Form reviewed and signed
- Hazard analysis, including review of Safety Data Sheet (SDS)
- Risk assessment
- Safety controls reviewed and applied to address risks (elimination, substitution, engineering controls, standard operating procedures, class size, special needs students, and personal protective equipment)
- PPE and other safety protocols documented in procedures
- Safety precautions handout prepared for teacher and students
- Safety precautions for chemicals reviewed and documented in procedures
- Safety precautions for physicals reviewed and documented in procedures (e.g., trip/fall hazards, projectiles, etc.)
- Safety precautions for biologicals reviewed and documented in procedures (e.g., blood-borne pathogen exposure, toxic plants, etc.)
- Safety precautions for hand and power tools reviewed and documented in procedures
- Lab/activity/demonstration performed by teacher prior to its use with students
- Plan in place to monitor behavior to assure safety requirements are being met during activity (e.g., making sure PPE stays on, maintaining proper distance from apparatus, etc.

Adapted from NSTA's Science Activity Safety Checklist.

Appendix D: List of Most Common Carcinogens

4-Nitrobiphenyl	Benzidine
Alpha-Naphthylamine	4-Aminodiphenyl
4,4′-Methylene bis (2-chloroaniline)	Ethyleneimine
Methyl chloromethyl ether	Beta-Propiolactone
3,3′-Dichlorobenzidine (and salts)	2-Acetylaminofluorene
Bis-Chloromethyl ether	Beta-Naphthylamine
4-Dimethylaminoazobenzene	N-Nitrosodimethylamine
Vinyl Chloride	Ethylene Oxide
Acrylonitrile	Cadmium
1,2-Dibromo-3 chloropropane	Butadiene
Inorganic Arsenic	Methylene Chloride

Appendix E: Example of Field Trip Medication Form

[Insert District Letterhead]

Name of Medication: _____

Dose (amount to be taken) _____

Time to be taken: _____

How it is taken: _____

I understand I must send the medication in the original container. All of the above information is on the label on the container prepared by the pharmacist as prescribed by:

_____ Doctor's Name

The following are any/all allergies or health conditions my child has:

_____

_____

Parent/Guardian Signature_____

Date_____

Please contact your school nurse if you have any questions.

School_____

District_____

Appendix F: Examples of Safety Products

The products listed below are intended as examples. The Delaware DOE does not endorse any specific product or supplier.

Chapter 1: Responsibilities in Instructional Spaces

Classroom Safety Posters

Laboratory Safety Posters

Laboratory Safety Contracts for Science Students

Heat-Resistant Safety Gloves

Chapter 3: General Instructional Guidelines

Eye Protection: Chemical Splash Lab Science Safety Goggles

Testing Flume Hoods: Laboratory Smoke Generators for Testing of Lab Fume Hoods

Eyewash: Wall-Mounted Emergency Eyewash Drench Hose

Safety Inspection Tags

Spill Control Kit

Microwave Use Warning Sign (Bilingual)

Free Laboratory Safety Signs to Download and Print

Safety Glasses:

Chapter 4: Instructional Areas using Rocketry, Mechanical, Electrical Lasers, and Ionized and Non-Ionized Radiation

Cable Protector to Prevent Trip Hazards

Free Laboratory Safety Signs to Download and Print

Chapter 6: Biology Guidelines

Refrigerator Safety Sign: OSHA Notice Sign: For Chemical Storage Only No Food Permitted

Chapter 7: Career and Technical Education Guidelines

Hearing Protection Products

Chapter 10: Technology and Engineering Education Guidelines

Hearing Protection Products

Appendix G: List of Extremely Hazardous Chemicals

Based on data from the Occupational Safety and Health Administration (OSHA), the Environmental Protection Agency (EPA), and the National Institute for Occupational Safety and Health (NIOSH), the following chemicals are classified as **extremely hazardous** due to their toxicity, flammability, reactivity, and environmental impact.

1. Acutely Toxic Chemicals (Poisonous & Lethal in Small Amounts)

- Arsine (AsH_3)
- Chlorine (Cl_2)
- Cyanides (Hydrogen Cyanide, Potassium Cyanide, Sodium Cyanide)
- Formaldehyde ($HCHO$)
- Hydrofluoric Acid (HF)
- Hydrogen Sulfide (H_2S)
- Mercury Compounds (Methylmercury, Mercury(II) Chloride)
- Phosgene ($COCl_2$)

2. Flammable & Explosive Chemicals

- Acetylene (C_2H_2)
- Benzene (C_6H_6)
- Ethanol (C_2H_5OH)
- Hydrogen Gas (H_2)
- Isopropyl Ether ($C_6H_{14}O$)
- Methanol (CH_3OH)
- Propane (C_3H_8)
- Toluene ($C_6H_5CH_3$)

3. Strong Oxidizers (Highly Reactive with Combustibles)

- Ammonium Nitrate (NH_4NO_3)
- Chlorates (Potassium Chlorate, Sodium Chlorate)
- Hydrogen Peroxide (H_2O_2) – at high concentrations
- Nitric Acid (HNO_3)
- Perchloric Acid ($HClO_4$)
- Potassium Permanganate ($KMnO_4$)
- Sodium Peroxide (Na_2O_2)

4. Reactive & Incompatible Chemicals

- Aluminum Powder (reacts violently with water)
- Bromine (Br_2)
- Fluorine (F_2)
- Lithium Metal (Li)
- Magnesium Powder (Mg)
- Sodium Metal (Na)
- White Phosphorus (P_4)

5. Carcinogenic & Mutagenic Chemicals (Cancer-Causing)

- Asbestos
- Benzene (C_6H_6)
- Chromium (VI) Compounds
- Formaldehyde (HCHO)
- Lead Compounds
- Polychlorinated Biphenyls (PCBs)
- Vinyl Chloride (C_2H_3Cl)

6. Highly Corrosive Acids & Bases

- Hydrochloric Acid (HCl)
- Hydrofluoric Acid (HF)
- Sulfuric Acid (H_2SO_4)
- Sodium Hydroxide (NaOH)
- Potassium Hydroxide (KOH)

7. Environmentally Hazardous Chemicals

- Dioxins
- PCBs (Polychlorinated Biphenyls)
- Pesticides (DDT, Aldrin, Chlordane)
- Per- and Polyfluoroalkyl Substances (PFAS)

Handling & Storage Guidelines

- Store chemicals according to compatibility categories (e.g., flammables separate from oxidizers).
- Use secondary containment for hazardous liquids to prevent spills.

- Label all chemicals according to GHS (Globally Harmonized System) standards.
- Maintain Safety Data Sheets (SDS) for each chemical.
- Train personnel in proper PPE usage and emergency procedures.

For more detailed information, refer to OSHA's Hazardous Chemical Guidelines and the EPA's Emergency Planning and Community Right-to-Know Act (EPCRA) requirements.

Appendix H: Chemical Storage Color Coding System

To ensure safe storage and handling of chemicals, a standardized **Chemical Storage Color Coding System** is used. This system helps in identifying chemical hazards, preventing incompatible chemical reactions, and improving workplace safety. Below is a common color-coded system for chemical storage, following guidelines from OSHA, NFPA, and EPA.

Color Coding System for Chemical Storage

1. Red – Flammable Chemicals

- **Examples:** Acetone, Benzene, Ethanol, Methanol, Toluene
- **Storage Guidelines:**
  - Store in a **flammable storage cabinet** away from heat sources.
  - Keep containers sealed when not in use.
  - Avoid oxidizers and ignition sources.

2. Yellow – Reactive & Oxidizing Chemicals

- **Examples:** Hydrogen Peroxide, Nitrates, Perchlorates, Chlorates
- **Storage Guidelines:**
  - Store separately from flammables and organic materials.
  - Use vented cabinets if necessary.
  - Avoid direct sunlight and heat.

3. Blue – Health Hazard/Toxic Chemicals

- **Examples:** Formaldehyde, Mercury Compounds, Cyanides, Lead Compounds
- **Storage Guidelines:**
  - Store in **well-ventilated areas**.
  - Ensure containers are tightly sealed.
  - Use proper **personal protective equipment (PPE)** when handling.

4. White – Corrosive Chemicals

- **Examples:** Hydrochloric Acid, Sulfuric Acid, Sodium Hydroxide, Ammonia

- **Storage Guidelines:**
  - Store in **corrosion-resistant cabinets**.
  - Separate acids and bases to prevent violent reactions.
  - Use appropriate spill containment measures.

5. Green – General Storage/Low Hazard Chemicals

- **Examples:** Salts, Sugars, Buffers, Non-hazardous Solvents
- **Storage Guidelines:**
  - Store in general storage areas.
  - Keep properly labeled and away from hazardous chemicals.

6. Orange – Peroxide-Forming Chemicals

- **Examples:** Ethers, Tetrahydrofuran (THF), Butadiene, Styrene
- **Storage Guidelines:**
  - Store away from heat and light.
  - Label with **expiration dates** and test regularly.
  - Avoid friction, shock, and contamination.

7. Gray – Non-Hazardous Chemicals

- **Examples:** Detergents, Sugars, Glycerol
- **Storage Guidelines:**
  - Store in **general lab storage**.
  - Ensure containers are **properly labeled**.

Storage Best Practices

- **Label all chemical containers clearly** with name, hazard information, and expiration date.
- **Segregate incompatible chemicals** using secondary containment bins.
- **Use ventilated storage** for volatile and toxic chemicals.
- **Store large containers on lower shelves** to reduce the risk of spills.
- **Check inventory regularly** and dispose of expired chemicals safely.
- **Follow OSHA, NFPA, and EPA regulations** to maintain compliance.

For more information, refer to OSHA's Hazard Communication Standard (HCS) and NFPA 704 Hazard Identification System guidelines.

Appendix I: Storage of Pressurized Liquids and Gases

Proper storage of pressurized liquids and gases is essential to ensure workplace safety and compliance with regulatory standards such as those from OSHA, NFPA, and EPA. **Incorrect storage** can result in leaks, explosions, or exposure hazards.

General Storage Guidelines

- Store cylinders upright and secured with chains or straps to prevent tipping.
- Ensure proper ventilation in storage areas to prevent gas accumulation.
- Keep pressurized containers away from heat sources, direct sunlight, and open flames.
- Label all containers clearly with contents, hazards, and handling instructions.
- Conduct regular inspections for leaks, damage, or expired cylinders.

Storage Classification and Segregation

1. Flammable Gases (Red Label)

- Examples: Acetylene, Hydrogen, Propane, Methane
- Storage Guidelines:
  - Store in a designated flammable gas area, away from oxidizers.
  - Use explosion-proof ventilation.
  - Keep away from ignition sources.

2. Oxidizing Gases (Yellow Label)

- Examples: Oxygen, Nitrous Oxide, Chlorine
- Storage Guidelines:
  - Store separately from flammable gases and combustibles.
  - Avoid oil and grease contamination.
  - Ensure proper ventilation to prevent oxygen-enriched environments.

3. Toxic and Corrosive Gases (Blue and White Labels)

- Examples: Ammonia, Carbon Monoxide, Chlorine, Hydrogen Sulfide

- Storage Guidelines:
  - Store in well-ventilated areas or gas cabinets.
  - Use leak detection systems and emergency ventilation.
  - Follow PPE requirements for handling.

4. Inert Gases (Green Label)

- Examples: Nitrogen, Argon, Helium
- Storage Guidelines:
  - Store separately from other gas categories.
  - Ensure proper ventilation to avoid asphyxiation hazards.
  - Secure cylinders to prevent tipping.

Handling and Usage Guidelines

- Use appropriate regulators and pressure relief devices.
- Always open valves slowly to prevent rapid pressurization.
- Never tamper with or remove safety devices from cylinders.
- Ensure that empty cylinders are marked and stored separately.
- Keep emergency shutoff valves accessible at all times.

Emergency Response and Disposal

- In case of a leak, evacuate the area immediately and follow the emergency response plan.
- Report damaged or expired cylinders to the supplier or designated safety personnel.
- Dispose of cylinders following EPA and local hazardous waste regulations.

By following these storage and handling guidelines, workplaces can minimize the risks associated with pressurized liquids and gases while maintaining compliance with safety standards. Always refer to OSHA, NFPA, and EPA regulations for the most up-to-date requirements.

Appendix J: Sample Chemical Inventory Form

This **Chemical Inventory Form** is designed to help track and manage chemicals used in a laboratory or workplace setting. It ensures compliance with OSHA, EPA, and NFPA regulations and promotes safety and accountability.

Sample Chemical Inventory Form

	Description
Date of Entry	_____
Chemical Name	_____
CAS Number	_____
Manufacturer	_____
Supplier	_____
Storage Location	_____
Container Size	_____
Quantity on Hand	_____
Physical State (Solid/Liquid/Gas)	_____
Hazard Classification (Flammable/Toxic/Corrosive/etc.)	_____
NFPA Rating (Health/Flammability/Reactivity)	_____
Expiration Date	_____
Safety Data Sheet (SDS) Available? (Yes/No)	_____
Responsible Person	_____
Disposal Method	_____

Instructions for Use:

1. **Record all chemicals** upon receipt and update the inventory regularly.
2. **Verify SDS availability** and ensure proper labeling of chemicals.
3. **Store chemicals in appropriate locations** based on compatibility guidelines.
4. **Track expiration dates** to prevent storage of outdated or unstable chemicals.

5. **Dispose of chemicals properly** according to local, state, and federal regulations.
6. **Assign responsibility** to an individual for maintaining inventory accuracy.

Regulatory Compliance:

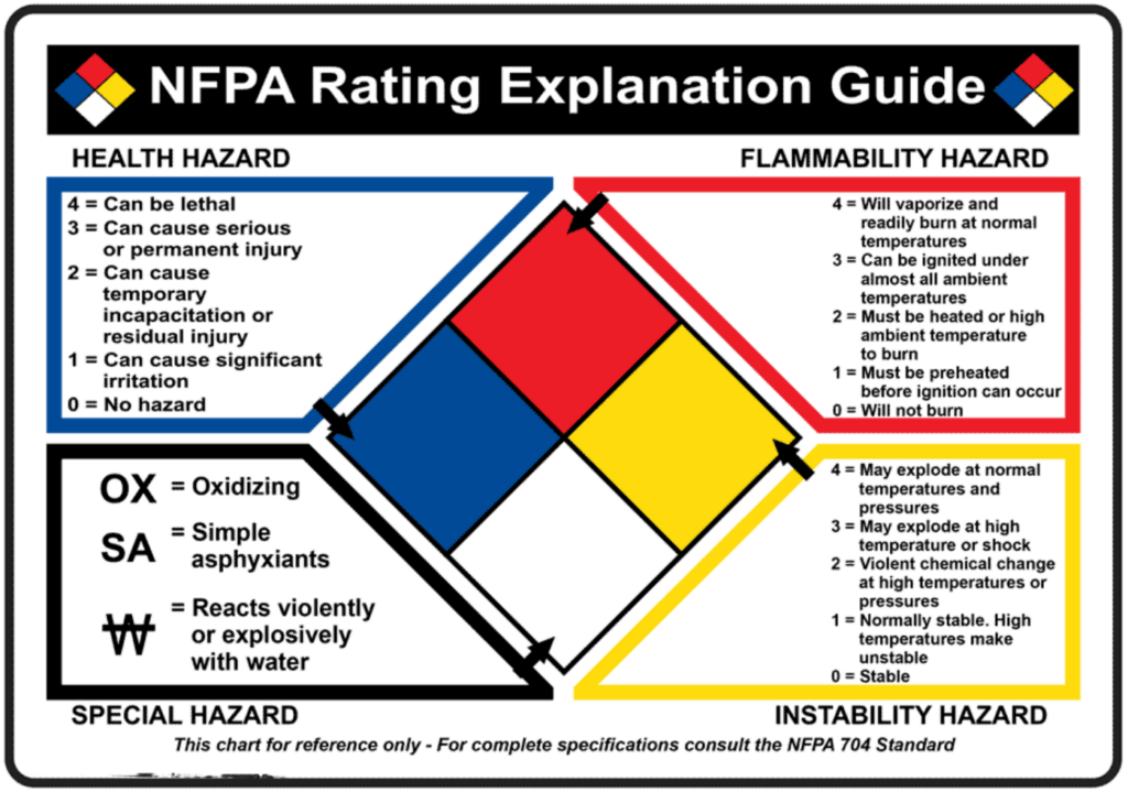
- This inventory form helps meet **OSHA Hazard Communication Standard (29 CFR 1910.1200)** requirements.
- Ensures compliance with **EPA hazardous waste management regulations**.
- Assists in emergency preparedness as recommended by **NFPA 704 Hazard Rating System**.

For further guidance, consult **OSHA, EPA, and NFPA** regulations on chemical management and safety.

Appendix K: NFPA Hazard Rating System

The **National Fire Protection Association (NFPA) Hazard Rating System** is a standardized method for identifying and classifying the hazards of materials. The system, commonly represented by the **NFPA 704 Diamond**, provides a quick visual indication of health, flammability, instability, and special hazards.

NFPA 704 Diamond Overview



The NFPA 704 label is divided into four color-coded quadrants:

Color	Hazard Type	Description
Blue	Health	Indicates toxicity or exposure risks to health.
Red	Flammability	Indicates how easily the material ignites.
Yellow	Instability (Reactivity)	Indicates the material's potential to react violently.
White	Special Hazard	e.g., corrosive, radioactive, water-reactive.

Hazard Ratings (0-4 Scale)

Each quadrant contains a number (0-4) representing the severity of the hazard:

Health Hazard (Blue Quadrant)

- **0** - No hazard
- **1** - Slight hazard; irritation or minor reversible injury possible
- **2** - Hazardous; temporary or minor residual injury likely
- **3** - Extreme danger; serious or permanent injury likely
- **4** - Deadly; exposure may be fatal

Flammability Hazard (Red Quadrant)

- **0** - Will not burn
- **1** - Must be preheated to burn
- **2** - Ignites when moderately heated
- **3** - Ignites at room temperature
- **4** - Extremely flammable; vaporizes rapidly

Instability (Reactivity) Hazard (Yellow Quadrant)

- **0** - Stable; not reactive with water
- **1** - Becomes unstable at high temperatures
- **2** - Violent chemical change possible
- **3** - May detonate under strong initiating conditions
- **4** - Explosive; capable of detonation

Special Hazard (White Quadrant)

- **OX** - Oxidizer (enhances combustion)
- **ACID** - Acidic material
- **ALK** - Alkaline material
- **COR** - Corrosive
- ☢ - Radiation hazard
- **W** (with a line through it) - Reacts violently with water

Usage and Compliance

- NFPA 704 labels are required in areas where hazardous materials are stored and used.
- They are typically found on **storage tanks, containers, pipelines, and facility entrances**.
- Employers must ensure that **workers understand NFPA labeling** and proper handling procedures.
- Compliance with **OSHA's Hazard Communication Standard (29 CFR 1910.1200)** is mandatory for chemical safety management.

For further guidance, refer to **NFPA 704: Standard System for the Identification of the Hazards of Materials for Emergency Response** and **OSHA's Hazard Communication regulations**.

Appendix L: Labels for Non-Chemical Refrigerators

Proper labeling of refrigerators designated for non-chemical storage is essential to prevent contamination, ensure food safety, and comply with workplace safety regulations. Below are standard labels and guidelines for ensuring clear identification of non-chemical refrigerators.

Standard Labeling Requirements

1. **Bold, Clear Text:** Labels should feature large, easy-to-read text such as:
    - "FOOD ONLY – NO CHEMICAL STORAGE"
    - "NO CHEMICALS ALLOWED"
    - "BIOLOGICAL SAMPLE STORAGE ONLY – NO FOOD OR DRINK"
2. **Color Coding:**
    - **Green Labels:** Indicate refrigerators approved for food and beverage storage.
    - **Blue Labels:** Designate refrigerators for biological sample storage only.
    - **Red Labels:** Clearly mark refrigerators restricted to chemical storage (if necessary for differentiation).
3. **Placement Guidelines:**
    - Labels should be **placed on the refrigerator door at eye level**.
    - Additional labels may be placed on **side panels** for extra visibility.
    - Use **durable, water-resistant labels** to withstand frequent cleaning and exposure to moisture.

Sample Label Designs

Food-Only Refrigerator

- **Text:** "FOOD ONLY"
- **Font Color:** White/Black for contrast

Biological Sample Refrigerator

- **Text:** "SPECIMENS ONLY – NO FOOD OR DRINK"

- **Background Color:** Blue
- **Font Color:** White/Black for contrast

Chemical Storage Warning

- **Text:** "NO FOOD OR DRINK – CHEMICAL STORAGE ONLY"
- **Background Color:** Red
- **Font Color:** White/Black for contrast

Compliance and Safety Considerations

- Labels must comply with **OSHA's Hazard Communication Standard (29 CFR 1910.1200)**.
- Institutions should conduct **regular inspections** to ensure labels remain intact and legible.
- Employees and students should be trained on **proper refrigerator usage policies**.

By implementing clear labels and consistent storage policies, organizations can **prevent cross-contamination, enhance safety, and maintain regulatory compliance**.

Appendix M: Biohazard Sign

A **Biohazard Sign** is crucial for indicating areas where biological hazards are present. This ensures the safety of personnel by providing clear warnings and compliance with OSHA, CDC, and WHO regulations.

Standard Biohazard Sign Elements

1. Required Text

- **BIOHAZARD** (Bold, uppercase letters)
- **AUTHORIZED PERSONNEL ONLY**
- **WEAR APPROPRIATE PPE** (if applicable)
- **CONTACT: [Responsible Person's Name & Phone Number]**

2. Symbol and Color

- **Biohazard Symbol** (Black, per OSHA 29 CFR 1910.1030)
- **Background Color:** Orange or Red
- **Font Color:** Black for visibility

3. Placement Guidelines

- Must be placed **at entry points to biohazardous areas**
- Should be **eye-level and clearly visible**
- Use **durable, weather-resistant materials** for longevity

Compliance and Safety Considerations

- Ensure compliance with **OSHA's Bloodborne Pathogens Standard (29 CFR 1910.1030)**.
- Regularly inspect and **replace faded or damaged signs**.
- Provide **training to personnel** on biohazard risks and precautions.

For further guidance, refer to **OSHA, CDC, and WHO** biohazard safety regulations.