THE NSTA READY-REFERENCE GUIDE TO SAFER SCIENCE

VOL. 3

Kenneth Russell Roy

NSTA press
National Science Teachers Association

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KENNETH RUSSELL ROY

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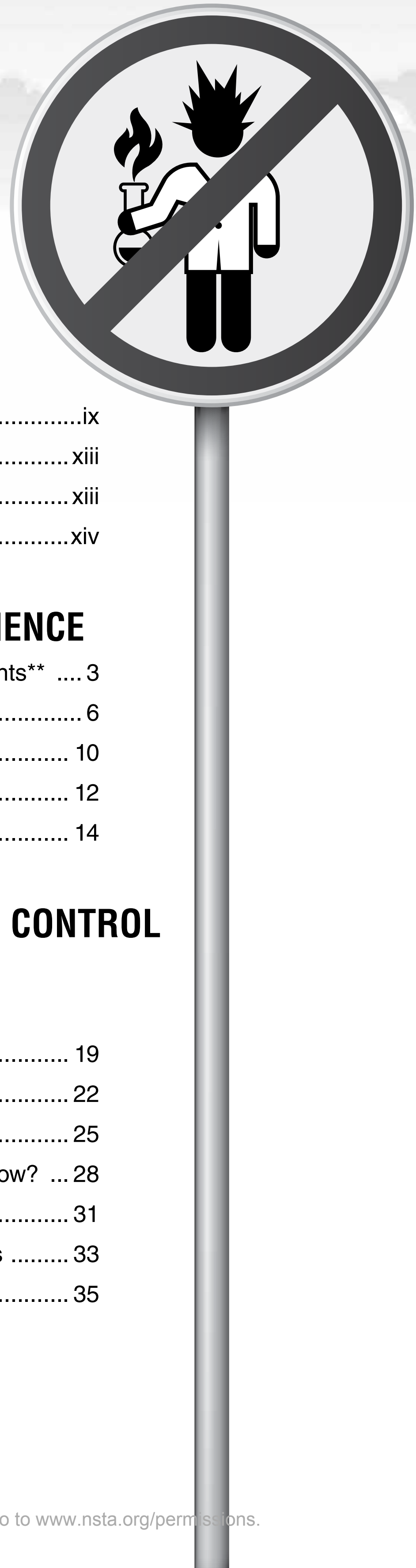

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∇ PREFACE

The role of activity-based science at the high school level, like the elementary and middle school levels, has swung like a pendulum since the 1950s. During the late 1950s and early 1960s, in the age of the Sputnik race, science education in the United States had a rebirth. Science education placed a focus on learning about science through the *doing* of science in an open classroom environment. A number of activity-based programs were developed with support from the National Science Foundation (NSF) and other private groups and companies. The "alphabet soup" programs—such as IPS (Introductory Physical Science), BSCS (Biological Sciences Curriculum Study), ESCP (Earth Science Curriculum Project) and more—fostered the introduction and expansion of laboratory period time in the school schedule. In the late 1980s through the early 1990s, these programs fell out of favor for a variety of curricular, administrative, and financial reasons. A return to the pre-1950s "textbook reading about science approach" again came into play. With this change came a reduction of the hands-on time allocated to science courses and, in some cases, the complete elimination of lab work.

Fast forward to the 1990s, when we saw the creation of the National Science Education Standards on the heels of *A Nation at Risk*, followed by No Child Left Behind legislation, and the development of curriculum programs such as AAAS Project 2061; NSTA's Scope, Sequence, and Coordination; state science frameworks; and more entered the science education stage. Thus began the rebirth of the "doing of science" approach in science education. As a result, scheduled laboratory time was once again either initiated or expanded in many high school science courses.

In 2012, the Next Generation Science Standards (NGSS) are being released with the goal of inspiring new generations of science and engineering professionals and scientifically literate citizens. Along with this goal comes a whole new challenge for safety in the science classroom, with an expanded emphasis on laboratory work. One potentially powerful engine embracing the NGSS is the science, technology, engineering, and mathematics (STEM) education approach, which is being adapted from comprehensive high school science curricula for STEM magnet high schools. This will present new safety challenges for science teachers when it comes to incorporating lab tools for technology education.

A second factor in the changes in science education during the early 1990s was the Occupational Safety and Health Administration (OSHA) unveiling and putting into effect a new federal law covering laboratory safety, known as 29 CFR 1910.1450, Occupational Exposure to Hazardous

Chemicals in Laboratories, or the Laboratory Standard. This law notifies general industry employers, including school boards of education, that they must provide a safe workplace in laboratories to deal with hazardous chemicals and the use of prudent practices.

In 2012, OSHA adopted the Globally Harmonized System of Classification and Labeling of Chemicals (GHS). The main purpose of GHS is to provide consistent information (health, physical, and environmental hazards) and definitions for hazardous chemicals based on the internationally accepted GHS. Adoption of this program has safety compliance implications for high school science teachers in the area of the OSHA Hazard Communication Standard and the Laboratory Standard.

A third factor that has influenced the direction of science education and safety is the focus on a more diverse student population, including groups such as special needs students. A series of legislative actions, such as the Americans With Disabilities Act (ADA), required that all students have the opportunities to participate in general education, including science education. Laboratory design and construction—in addition to curriculum, instruction, and safety strategies—must attempt to address these needs.

The fourth factor is the revolution taking place in the cadre of science educators. As in the late 1960s and 1970s, many science educators are reaching retirement age and leaving the profession. As these educators retire, science education loses many years of professional experience and knowledge. Neophytes are taking these teachers' places, with limited experience in laboratory work and little to no safety preparation.

The fifth factor is the economic downturn worldwide during the last decade. Economic struggles have affected supply-intensive disciplines such as science at both the elementary and secondary levels. "Provide more by using less" has been the operative strategy. This strategy certainly has put limits on the science curriculum, instruction, and safety.

The last important factor is liability. We are still living in a litigious society in which teachers are held to very high standards. Teachers and administrators need to become aware of and concerned about liability for their actions. This is especially of interest to science teachers at the high school level, given the potential safety issues they face by working with students in formal laboratories and the field.

All of these factors have science teachers asking how they can improve safety in their laboratories and still carry out meaningful activities. To address some of these challenges relative to safety, the National Science Teachers Association (NSTA) introduced the safety column "Safer Science" in *The Science Teacher*, a journal for high school science teachers. The purpose of the column—which was modeled after the safety column in *Science Scope*, NSTA's middle school journal—was simple: provide safety information for science teachers that will help them address safety issues when dealing with hands-on instruction in the laboratory and the field.

This book is a compendium of articles from the inception of the column in 2007 to the present. The articles are based on inquiries from science teachers nationwide. The topics focus on everyday safety issues that high school science teachers and supervisors deal with when doing science. Each column is written to help science teachers become aware of legal standards and prudent practices that make for safer laboratory experiences and protect both students and teachers. Unfortunately, as at the middle school level, some architects, building contractors, school administrators, and board of education members have taken advantage of high school science teachers on issues such as facility design, occupancy loads, and protective equipment. This has happened because science teachers lack the expertise—in both knowledge and experience—in legal building and safety standards and prudent practices in the laboratory. Unsafe laboratory activities and facilities can get science teachers into legal challenges with professional and civil consequences.

This book is divided into three areas. The first section is a short introduction to the topics of hands-on science for all students, as well as the protection afforded to the science teacher through the OSHA Laboratory Standard. The second section addresses safety practices and legal standards, with a focus on current issues facing science teachers relative to engineering controls, administrative controls, and personal protective equipment. The final section provides appendixes, including relevant NSTA position papers and internet resources.

Safer science is critical for the teacher as an instructor and employee and for the student as a learner and citizen. Learning to teach and practice safer science is a lifelong endeavor, and I hope you will join me in this process.

Ken Roy

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I wish to especially thank several people who have helped beyond expectations to make the journal safety columns highly effective for in-the-trenches science teachers and school administrators. Thanks to *The Science Teacher*'s managing editor, Scott Stuckey; former associate editor, Meg Streker; and field editor, Steve Metz, for their guidance and direction in the development and operation of the column over the years. Thanks goes to David Beacom, publisher at NSTA, for his continued support and action relative to addressing safety issues in NSTA publications. Additional thanks goes to attorney Harold R. Cummings of Cummings, Lanza & Purnhagen, LLC law firm (South Windsor, CT) and attorney Kelly Ryan of The Ryan Law Firm (Pasadena, CA), for their professional reviews and contributions to many safety articles. A special thanks goes to my dermatologist, Andrew V. Atton, MD, of Dermatology Associates of Glastonbury (CT). My appreciation is for not only his professional contributions to several articles but also his detection skills and successful treatment of a serious health issue I had. Final acknowledgement goes to my wife, Marisa; my two daughters, Lisa Marie Bride and Louise Irene Roy; and my grandson, Michael Patrick Bride, for their continued support, understanding, and patience.

▽ ABOUT THE AUTHOR

Dr. Kenneth Russell Roy has been a science educator, K–12 administrator, and safety compliance officer for more than 44 years. In addition, he has a large number of experiences as an author and editor, with more than 200 published articles and 4 books dealing with science education and laboratory safety. He has served in numerous leadership positions for state, national, and international science education organizations. He currently serves as the director of environmental health and safety for Glastonbury Public Schools (Glastonbury, CT). Dr. Roy is also an independent safety consultant and advisor working for professional organizations, school districts, magnet schools, insurance companies, textbook publishers, and other organizations dealing with safety and science education issues.

Dr. Roy earned a bachelor's degree in science in 1968 and a master's degree in 1974, both from Central Connecticut State University, and a doctorate in 1985 from the University of Connecticut. In addition, he received a diploma in professional education from the University of Connecticut in 1981 and has a certificate of instruction as an authorized OSHA instructor from the Keene State College OSHA (Office of Safety and Health Administration) Extension School.

Dr. Roy is a past chairperson of the NSTA Science Safety Advisory Board and also the NSTA Science Safety Compliance Consultant, serving as NSTA's liaison to the board. He is an NSTA author and safety columnist.

ABOUT THIS BOOK

Beginning in September 2007, *The Science Teacher* started publishing the column "Safer Science" in each issue. In the column, author Ken Roy, NSTA Science Safety Consultant and past chairperson for the NSTA Safety Advisory Board, shares the knowledge, skills, and attitudes that help guide planning for safer science instruction. This book includes information, anecdotes, advisories, warnings, and good leads to the newest resources for high school teachers in their quest for safer science instruction.

This book is a compilation of updated safety columns and covers a wide range of safety issues in quick-reference form. You can use the index or the table of contents to locate a quick answer to your questions about practicing safer science.

Science teachers are charged with meeting "duty of care." They must therefore make decisions based on the maturity and knowledge base of their students. This responsibility is in concert with students' exposure to the potential hazards associated with hands-on activities in laboratories and the field. The charge is clear: to secure and foster safer learning and working environments for both students and teachers.

Given the advances in the natural sciences and the resulting sophistication of the laboratory experience, high school science teachers must be prepared to deal with what might happen when we least expect it. For a safer laboratory learning environment, high school teachers must not only keep up-to-date with the latest information about products, hazards, and best practices but also consider the developmental levels and health statuses of their students.

To better meet their responsibility of duty of care for their students, it is critical that high school science teachers stay in tune with current legal standards and professional best practices. A good place to start is by reading this book!

I

INTRODUCTION TO SAFETY IN SCIENCE

INTRODUCTION TO SAFETY IN SCIENCE

1. Making Adjustments for Mobility-Impaired Students

In 1985, the year Halley's Comet last passed near Earth, the American Association for the Advancement of Science (AAAS) initiated Project 2061. *Science for All Americans*, the project's cornerstone publication, was recognized as the first step in establishing national standards in science for all students, including those with disabilities. With the help of this project and legislation such as the Americans With Disabilities Act (ADA), individuals with disabilities are assured equal opportunity and full participation in school and out. As a result, accommodations must be made to help disabled students fully participate in science classrooms and laboratories, including making the laboratory accessible to students with mobility impairments.

Given the variety of needs relative to science, lab facilities, and each student's physical abilities, no spectral standards exist for establishing science laboratories. However, several sources do exist for specific guidelines that should serve as the basis for design considerations in constructing or renovating science laboratories, which can help provide both access and safer science for students with disabilities. These include the ADA, created to eliminate discrimination against persons with disabilities; the Uniform Federal Accessibility Standards (UFAS) for facility accessibility for physically handicapped persons in schools receiving federal financial assistance; and state and local regulations. (*Note:* See Internet Resources for a list of helpful resources.)

Students' mobility impairments need to be addressed for access to and safety in science laboratories. Typical accommodations for mobility-impaired students include workstations, sinks, fume hoods, and safety eyewashes and showers, in addition to other adaptations. The following are some of the higher-profile accommodations based primarily on ADA and UFAS expectations for mobility-impaired students and faculty members. It should be noted that the ADA and UFAS are not always in agreement, as UFAS tends to be more restrictive in some cases. Be sure to check local and state regulations as well.

Laboratory Workstations

The traditional science laboratory workstation is equipped with electrical receptacles, gas jets, water faucets, sinks, and apparatus rod sockets. Controls for these fixtures should be easy to operate using a maximum of 2.3 kg (5 lbs.) of force and should also require only a loose grip to operate, as opposed to pinching the fingers or twisting the wrist. Single-action lever controls should be used in place of knob-type controls.

At least one workstation should be designed to accommodate students with mobility impairments. Dimensions for access to this workstation should include a maximum height of 86 cm (34 in.) from the floor to the work surface. Accommodating dimensions for knee space should be 69 (height) × 76 (width) × 48 cm (depth) (27 × 30 × 19 in.). Clear floor space with dimensions of 76 (width) × 122 cm (length) (30 × 48 in.) is required for a wheelchair front approach, with adequate space provided to maneuver to and from the workstation. In addition, the workstation should be in a place with no physical barriers and allow for visual access to instruction and demonstrations. Mirrors or electronic camera devices can also help provide visual access.

Laboratory Sinks

ADA Accessibility Guidelines (ADAAG) for Buildings and Facilities specify that sink depth in the laboratory should be no more than 16.5 cm (6.5 in.) so that a wheelchair can fit under the sink. The minimum knee space required is 69 × 76 × 48 cm. The counter or rim of the sink must be mounted at a maximum height of 86 cm from the finished floor. Faucets should have easy access, lever-operated controls, or a similar alternative, such as push-type, touch-type, or electronically controlled mechanisms. Clear floor space with dimensions of 76 × 122 cm is also required for laboratory sinks. Exposed hot water and drain pipes under sinks are to be insulated or configured to protect against contact. In addition, to avoid injury, there should be no abrasive or sharp surfaces under the sinks.

Fume Hoods

As with workstations and lab sinks, fume-hood decks should also be lowered to the required maximum height of 86 cm from the finished floor. Required knee space is also the same (69 × 76 × 48 cm), as is the required floor space (76 × 122 cm). Easily operable hood controls should be placed at a maximum height of 122 cm; this height is referenced by the International Building Code (IBC/ANSI A117.1) for new construction and is a requirement for state departments of education and other jurisdictions using this code. However, existing installations that have controls within 137 cm (54 in.) of the floor may remain at this height.

Safety Eyewashes and Showers

Modifications to the standard safety-eyewash station bowl and the pull-handle shower are also required. The eyewash bowl should be lowered so that the maximum height of the water-discharge outlets is 91 cm (36 in.) above the finished floor. For new showers, the pull handle should be at a maximum height of 122 cm above the floor to accommodate a wheelchair side approach—this is a requirement for state departments of education and other jurisdictions using this code. Existing shower installations that have the pull handle within 137 cm of the floor may remain at this height. Clear floor space of 76 × 122 cm is also required for the shower. (*Note*: Flexible-hose-type showers installed in the laboratory stations are not permitted by the Occupational Safety and Health Administration [OSHA] as the sole means of providing this safety feature.)

Additional Access Items

The sharp corners of cabinets, bookcases, and other equipment or furniture also need to be addressed. Alternative laboratory storage units, such as a storage cabinet on rollers, can be helpful in this regard. Items on storage shelving must be a maximum of 122 cm above the finished floor for easy and safe access from a wheelchair side approach—again, this is a requirement for state departments of education and other jurisdictions using this code. Adequate maneuvering space and accessible hardware (similar to controls described in the sections Laboratory Workstations, Laboratory Sinks, and Fume Hoods) are required to ease the opening of cabinet doors. Existing installations that store items within 137 cm of the floor may remain at this height.

In cases where specific equipment is required, adaptations are often available. For example, extended eyepieces for microscope viewing can be secured for students' use in wheelchairs. Another example is glassware such as beakers with handles for easier access and use.

Finally, doorway width should be a minimum of 81 cm (32 in.) for wheelchair clearance, and aisle width should be a minimum of 91 cm. For mobility clearance, a turning radius of 152 cm (60 in.) is needed.

If teachers have concerns about accommodations and safety in their own laboratory, they should contact the building administrator in writing. Ultimately, it is up to the administration to provide alternatives, such as a portable unit, needed to meet ADA specifications.

A safer laboratory for all students involves keeping the designed laboratory landscape uncluttered. Laboratories that are messy or poorly designed foster trip-and-fall hazards and other safety incidents, which can put both students and teachers in harm's way.

Acknowledgments

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Resource

Motz, L. L., J. T. Biehle, and S. S. West. 2007. *NSTA guide to planning school science facilities.* 2nd ed. Arlington, VA: NSTA Press.

Internet Resources

International Code Council: *www.iccsafe.org*

United States Access Board. ADA Accessibility Guidelines for Buildings and Facilities (ADAAG). *www.access-board.gov/adaag/html/adaag.htm#4.244*

United States Access Board. Uniform Federal Accessibility Standards (UFAS). *www.access-board.gov/ufas/ufas-html/ufas.htm*

2. Laboratory Safety: Welcome Aboard!

Why did *The Science Teacher* initiate a safety column? Walk into a typical science classroom today and you are likely to see the teacher conducting a demonstration or students doing hands-on laboratory work. This key instructional strategy has been re-embraced since the advent of the *National Science Education Standards*, state science curriculum reforms, and No Child Left Behind legislation. In the mix of these initiatives is a major retirement revolution and effects of the economic downturn. Teachers with many years of skill and knowledge in laboratory work are coming of age to leave the profession. In addition, a myriad of schools need renovations or new construction because of overcrowded conditions and outdated laboratory facilities. Some of these issues unfortunately have not been addressed due to limited funding.

Safety in the science laboratory and field work is all the more important as a result of these events and changes. The mission of this column is to address the "in the trenches" safety issues and help teachers successfully maneuver through these revolutionary and evolutionary times in science education.

OSHA Laboratory Standard: The Locomotive Driving Safety

Where does a science teacher or supervisor start to ensure that laboratory work is conducted with safety in mind? Federal government legislation from 1990 is the major force in helping establish a safe working environment in academic laboratories for teachers and students. This legislation is based on the Occupational Safety and Health Administration's (OSHA) Occupational Exposure to Hazardous Chemicals in Laboratories, otherwise known as the Science Laboratory Standard for employees working in laboratories.

All school employees protected under Federal OSHA or similar state plans are covered by the 1986 Hazard Communication Standard or HazCom/Right to Know law (29 CFR 1910.1200). However, as of 1990, because of the dangers and uniqueness inherent in laboratory work, employers under Federal OSHA or similar state plans are required to cover laboratory workers specifically (including science teachers) with the OSHA Laboratory Standard (29 CFR 1910.1450 Subpart Z).

Moving on the Right Track

The OSHA Laboratory Standard is performance based. OSHA provides the basic outline requirements, then each employer (e.g., board of education) writes a plan tailored to its independent needs. For example, plans may vary from district to district relative to differing standard operating procedures, but all plans must contain standard operating procedures.

Three important components of the standard include the development of a chemical hygiene plan (CHP), the appointment of a chemical hygiene officer (CHO), and employee training. The written CHP must be developed to protect employees from hazards associated with chemicals in the laboratory. Although generic plans are available, each plan must be unique to address the specific needs of individual workplaces. The employer is responsible for developing and enforcing the plan. The standard also requires that the employer appoint a CHO to develop and implement the CHP. The CHO position is an appointment under the OSHA standard as opposed to a required new hiring.

The CHP Itinerary

OSHA requires the CHP be composed of the following minimum parts:

- Standard operating procedures (SOPs): What are the standards for laboratory operation that all employees are required to follow? For example, what is the protocol for testing showers and eyewash stations in laboratories? SOPs should be rooted in standards, codes, or other professional expectations.
- Criteria to determine and implement control measures to reduce employee exposure: What type of engineering controls (e.g., eyewash stations), use of personal protective equipment (e.g., chemical-splash goggles), and hygiene practices (hand washing) are required?
- Requirement that fume hoods and other engineering controls are functioning properly and within specific measures: Is there a preventive maintenance program in place that fosters optimal performance of engineering controls?
- Provisions for employee information and training: What types of (and how much) safety training and information are provided for employees?
- Circumstances where laboratory operation requires prior approval from the employer: What is the protocol used to undertake a special laboratory activity or new procedure?
- Provisions for medical consultation and examinations: What procedure has been established to provide for medical assistance if an employee has a chemical exposure or incident?
- Designation of personnel responsible for implementation of CHP, including CHO: Who is the employer-designated CHO? This person—often a chemistry teacher, department head, or laboratory technician—must be qualified by training or experience to provide technical guidance in the development and implementation of the CHP.
- Provision for additional employee protection when working with particularly hazardous substances: What procedures are in place for employees if they

work with substances such as toxins and flammables?

Making the Connection for Training

The CHP must include employee information and training relevant to laboratory work. The training must be provided at the time of initial employment and when new chemicals or hazards are introduced into the workplace. Information must include CHP contents, laboratory standards, personal exposure levels (PEL), threshold limit values (TLV), exposure signs, and the location of related reference materials. Training must minimally include methods to detect the presence of hazardous chemicals, physical and chemical health hazards in the laboratory or work area, procedures such as emergency procedures, work practices, and protective equipment.

Additional Items to Consider

Remember, OSHA standards represent only the minimum expectations for safety. Also, OSHA covers employees, not students. However, to maintain a safer working environment for employees such as science teachers, the school's CHP should also include students. The rationale is that to maintain a safer working environment for teachers as employees, students must also be accountable for following SOPs in the lab.

Those working with the employer in the development of the CHP need to consider additional policies and regulations that go beyond the minimal safety expectations, such as the following:

- Use of lab facility: The CHP should address policies on use of laboratories by noncertified instructors and nonscience students—for example, the assignment of study halls or English classes to science laboratories.
- Occupancy load: Legal standards such as fire and building codes restrict occupancy loads in science laboratories. Quasi-legal and professional standards provide academic occupancy loads in science labs. This in effect limits the number of occupants allowed in a science laboratory. Be careful to distinguish between the terms *science laboratory* and *science classroom*. Those designations have different ramifications relative to code applications.
- Security: Science laboratories are considered secured areas, given the inherent dangers from elements such as gas, electricity, and hazardous chemicals. Policies need to be written to foster security relative to entering laboratories and storerooms. For example, only chemistry teachers are provided with a key to the chemical storeroom. Science laboratories should be locked when they are not in use.
- Special needs: Policies in working with students or employees who are physically challenged or have other special needs should be addressed in the CHP. A

variety of options are available to meet both the safety and educational needs of all students and employees in the laboratory.

All Aboard for Safety's Sake

The OSHA Laboratory Standard is the foundation for an effective laboratory safety program. Science teachers and school administrators need to be advocates for safer science in the laboratory or field. They must help educate central office administrators, board of education members, and legislators and other government officials to promote and facilitate a safer working environment for employees and students. Science teachers who make safety a priority for their students will not only make the lab safer for themselves but also will instill a commitment on the part of their students as future employees.

Internet Resources

Occupational Safety and Health Administration (OSHA). Occupational Safety and Health Administration laboratories, other resources. *www.osha.gov/SLTC/laboratories/otherresources.html*

Occupational Safety and Health Administration (OSHA). Occupational Safety and Health Administration laboratory standard. *www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10106*

3. Good-Bye MSDS, Hello SDS!

Science teachers who use the Material Safety Data Sheet (MSDS)—a form listing the properties of a particular substance—know that the potential hazards identified by different suppliers aren't always consistent. Unfortunately, this issue goes well beyond the secondary science laboratory—it's a global problem.

The Occupational Safety and Health Administration (OSHA) addressed this issue and other concerns with the adoption of a rule to change the Hazard Communication Standard (HCS), a national standard that addresses chemical management and employee safety. OSHA's new rule includes the adoption of the Globally Harmonized System for the Classification and Labeling of Chemicals (GHS)—a standardized system created by the United Nations to provide a worldwide standard for safety hazards—into the HCS. The goals of the GHS are to

- provide consistent information (e.g., health, physical, and environmental hazards) and definitions for hazardous chemicals,
- establish a standard format for Safety Data Sheets (SDS) and labels, and
- increase understanding by using standardized pictograms and harmonized hazard statements.

With the adoption of the GHS, the revised HCS will include the following major changes:

- Hazard classification: Chemical manufacturers will be expected to use specific criteria to classify health and physical hazards for pure chemicals and mixtures.
- Labels: Chemical manufacturers and importers will be mandated to provide precautions and labels that include signal words, pictograms, and hazard statements for each hazard class and category.
- SDS: The SDS will have a 16-section format with specific categories and information and will replace the existing MSDS.
- Information and training: Although the GHS does not address training, the proposed HCS will require that workers be trained within two years of the publication of the final rule.

Specific Changes

The existing HCS is performance based. It provides guidance for hazard determination but doesn't specify an approach, format, or language to convey hazards and other information on labels or MSDS. The new GHS has performance-based aspects, but the key provisions are uniformity oriented. For example, Health Hazards categories will be classified and defined via GHS protocols.

The new standard format for SDS includes these sections:

1. identification
2. hazard(s) identification
3. composition and information on ingredients

4. first-aid measures
5. firefighting measures
6. accidental release measures
7. handling and storage
8. exposure control and personal protection
9. physical and chemical properties
10. stability and reactivity
11. toxicological information
12. ecological information
13. disposal considerations
14. transport information
15. regulatory information
16. other information

OSHA will probably not enforce the sections that require information outside of its jurisdiction (i.e., #12–16).

Labeling is another improvement. Labels will include

- the product name,
- a signal word (e.g., *danger* or *warning*),
- a hazard statement (explaining the nature and degree of risk),
- pictograms and symbols,
- a precautionary statement (how the product should be handled to minimize risks),
- the name and address of the company, and
- telephone numbers.

In the End

All of these changes will help science teachers better assess the risk of using hazardous chemicals in the laboratory.

Science teachers can track regulation changes and the adoption process on OSHA's website (see Internet Resource).

Internet Resource

Globally Harmonized System for Hazard Communication: *www.osha.gov/dsg/hazcom/global.html*

4. NSTA Portal to Science Safety

Since the publication of the *National Science Education Standards* (NRC 1996), high school science has become more hands-on and more process- and inquiry-based. With this "doing" of science comes a greater need for safety training and preparedness for science educators. The many legal standards and best practices require that a safety approach protect both students and teachers. Where can a science teacher find resources to help meet this need?

The National Science Teachers Association's (NSTA) Science Safety Advisory Board launched the Safety in the Science Classroom portal for just this reason (see Internet Resource). The portal is a gateway to safety resources for teachers, supervisors, and administrators. The first resource listed is the *OSHA Training Requirements and Guidelines for K–14 School Personnel.* This document provides a definitive summary of all relevant Occupational Safety and Health Administration (OSHA) requirements and guidelines and points out the varied legal requirements at both national and state levels. These requirements are mandated for most school employers (e.g., boards of education) in training employees (e.g., teachers, supervisors, and administrators).

The Safety in the Science Classroom portal also contains an evolving list of safety resources for elementary, middle, and high schools. The list includes professional societies, federal and state agencies, nonprofit and for-profit companies, and science supply houses that provide safety services and products for K–12 schools. All of the for-profit companies on the list offer free materials or services.

What kind of resources can teachers expect to find on this list? Here are some safety resources that may be of interest:

- American Association of Poison Control Centers: poison prevention resources and tips
- American Chemical Society: chemical storage resources and numerous publications, including *Safety in Academic Chemistry Laboratories* and *Recommendations for Goggle Cleaning*
- Centers for Disease Control and Prevention: *School Chemistry Laboratory Safety Guide*
- Cole-Parmer: the Chemical Resistance Database
- Council of State Science Supervisors: *Science and Safety, Making the Connection*
- Environmental Protection Agency: the School Chemical Cleanout Campaign (SC3) and the *Chemical Management Resource Guide for School Administrators*
- Flinn Scientific: *Chemical Hygiene Plan* and other resources on overcrowding in science labs
- The Hartford: *An Overview of OSHA's Laboratory Standard 29 CFR 1910.1450*

- Laboratory Safety Institute: many safety publications
- Local Hazardous Waste Program in King County Metro (Seattle): *Rehab the Lab*, an advisory list of acceptable chemical uses
- Massachusetts Institute of Technology: *Tips for Sustainable Solvent Practice* and the *Generic Solvents Alternative Guide*
- National Institutes of Health: the Household Products Material Safety Data Sheets (MSDS) Database
- National Oceanic and Atmospheric Administration: a chemical database with response recommendations for over 6,000 chemicals
- National Science Education Leadership Association (NSELA): NSELA professional safety practice position statements, including Occupancy Loads in School Science Laboratories and Experiments/Activities With Human Blood and Other Potentially Infectious Materials (OPIMS)
- NSTA: NSTA position statements—including Liability of Science Educators for Laboratory Safety—and many books on safety
- Science and Safety Consulting Services: *Chemical Substitution List* and Eye Protection Options poster
- Virginia State Department of Education: *Safety in Science Teaching* manual
- Web resources for MSDS

Final Thought

The Safety in the Science Classroom portal contains a list of valuable resources for science educators. Teachers should be aware that the list does not supersede school, local, state, or federal laws; regulations; codes; or professional standards. Ultimately, it is the science teacher's and school administrators' responsibility to make science safer using appropriate legal standards and best professional practices under the "duty of care."

Author's Note

Any for-profit company that provides free materials or services to K–12 schools and wishes to be listed on the Safety in the Science Classroom portal should send a request to Ken Roy at *royk@glastonburyus.org.*

Reference

National Research Council (NRC). 1996. *National science education standards.* Washington, DC: National Academies Press.

Internet Resource

National Science Teachers Association (NSTA). Safety in the Science Classroom portal: *www.nsta.org/portals/safety.aspx*

5. Getting Students in the Safety Zone

There are no existing federal laws that protect students through health and safety programs in school science laboratories or schools in general. Yet the Federal Occupational Safety and Health Administration (OSHA) Health and Safety Act of 1970 requires that school employers provide health and safety programs for teachers and other school employees. The question is, How can the work environments of science teachers reflect health and safety standards if there are no similar requirements for students? The answer is that they cannot, unless the school district institutes safety protocols and practices for students to follow.

The *School Chemistry Laboratory Safety Guide* is a resource for science teachers and school administrators to consider for this purpose. This publication from the National Institute for Occupational Safety and Health (NIOSH) is available online (see Internet Resource). Although the guide is designed for chemistry classes, it also provides best practices for biology, physics, and Earth and space science.

Experience Counts

When reviewing occupational injury data, it becomes clear that the rate of injury depends on experience, or lack thereof. Higher frequencies of injury occur during an individual's initial period of employment but decrease with more experience. Similarly, the likelihood of a safety incident is higher when students engage in new activities. To help reduce the number of safety incidents and make the environment safer for both students and employees, science teachers must provide lab safety training and enforcement for their students.

Given their "duty of care," science teachers are obligated to provide instruction on legal standards and best safety practices. This involves safety information and resources, training, direct supervision, and enforcement. The lab experience provides the opportunity for teachers to help students develop life skills in safety and health.

Ultimately, it is the responsibility of the teacher's employer—the board of education—to provide a safe working environment for students and employees (i.e., teachers). Administrators and supervisors representing the employer must provide professional development and safety resources (e.g., appropriate engineering controls, standard operating procedures, and personal protective equipment) for employees and students in all science labs.

Building Student Attitudes

The *School Chemistry Laboratory Safety Guide* covers just about every aspect of lab safety needed for the operation of a safer science program. The guide addresses issues dealing with engineering controls, hazardous waste, chemical hazards assessment, lab signage, Material Safety Data Sheets (MSDS), chemical hygiene plans (CHPs), cradle-to-grave chemical cycles (i.e., ordering, use, storage, and disposal), inventory, best practices, and more.

One important piece of information the publication provides is a student safety checklist—a set of dos and don'ts for lab behavior and practice. The checklist also aims to build positive attitudes about safety and protect both students and teachers in the lab. The guide's major topics include some of the following example items (*Note:* These examples are adapted from the NIOSH guide. The full checklist is available online [see Internet Resource]):

- Conduct: The use of personal audio or video equipment is prohibited in the lab. Do not engage in practical jokes or boisterous conduct in the lab.
- General work procedure: Coats, bags, and other personal items must be stored in designated areas, not on the bench tops or in the aisles. Notify your teacher of any known sensitivities you have to particular chemicals.
- Housekeeping: Inspect all equipment for damage (e.g., cracks and defects) prior to use; do not use damaged equipment. Properly dispose of broken glassware and other sharp objects immediately in designated containers.
- Apparel in the lab: Wear shoes that adequately cover the whole foot; low-heel shoes with nonslip soles are preferable. Do not wear sandals, open-toe shoes, open-back shoes, or high-heel shoes in the lab.
- Hygiene practices: Remove any protective equipment (i.e., gloves, lab apron, chemical-splash goggles) before leaving the lab. Food and drink—open or closed—should never be brought into the lab or chemical storage area.
- Emergency procedures: In case of an emergency or accident, follow the established emergency plan and evacuate the building through the nearest exit. Know the location of and how to operate the following: fire extinguishers, alarm systems with pull stations, fire blankets, eyewashes, first-aid kits, and deluge safety showers.
- Chemical handling: Use the chemical hood, if available, when there is a possible release of toxic chemical vapors, dust, or gases. When using a hood, the sash opening should be kept at a minimum to protect the user and ensure efficient operation of the hood. Keep your head and body outside of the hood's face. Chemicals and equipment should be placed at least 15 cm (6 in.) within the hood to ensure proper air flow. When transporting chemicals (especially 250 ml or more), place the immediate container in a secondary container or bucket (made of rubber, metal, or plastic) that is large enough to hold the entire contents of the chemical and can be carried easily.

Final Safety Thought

Remember that students coming into science labs need initial and ongoing training about safety standards and best practices. They also need to develop good attitudes about their work and the health and safety of their teachers and fellow students. The *School Chemistry Laboratory Safety Guide* provides a helpful resource to move students into the safety zone.

Internet Resource

Centers for Disease Control and Prevention (CDC). *School chemistry laboratory safety guide. www.cdc.gov/niosh/docs/2007-107*

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THE NSTA READY-REFERENCE GUIDE TO

SAFER SCIENCE

VOL. 3

"The changing safety legal standards and professional best practices affecting academic laboratories are efforts to match the rise of modern science's discoveries and applications. Unfortunately, teacher preservice preparation and inservice professional development have not kept pace with these changes. This volume helps bridge the gap by raising awareness of safety issues and showing how to develop a safer learning and working environment in schools."

—Ken Roy on *The NSTA Ready-Reference Guides to Safer Science*

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The book covers important information, such as

- systems to help prevent and control lab safety hazards, from eyewash showers to ventilation;
- standard operating procedures covering general safety precautions and safety in specific disciplines, such as biology, chemistry, Earth and space science, and physical science;
- personal protective equipment; and
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Learn more with these other great resources:

The NSTA Ready-Reference Guide to Safer Science, Volume 1, for grades 5–8: The articles in this volume cover more safety practices and legal standards (on subjects from asbestos to ergonomics to blood-borne pathogens) and instructional safety (such as occupancy loads, fields trips, special-needs students, and more).

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