THE NSTA READY-REFERENCE GUIDE TO

SAFER SCIENCE

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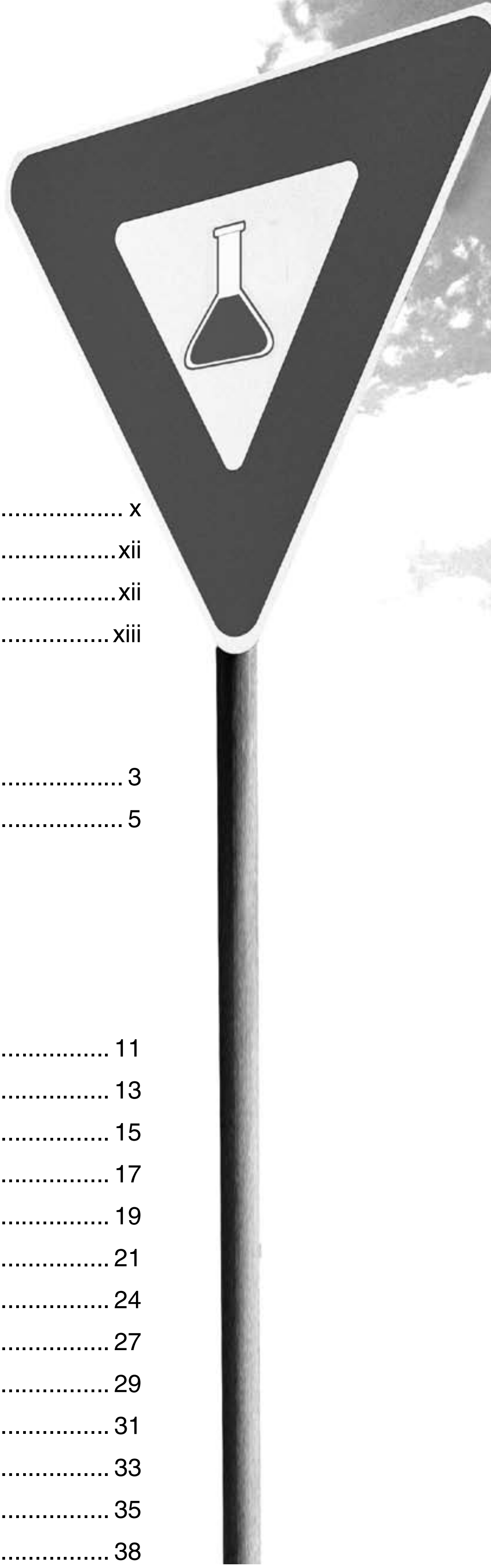

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PREFACE

As the French say, "Plus ca change, plus c'est la meme chose." "The more things change, the more they stay the same." This is the case with learning science in the classroom by "doing" hands-on activities. During the late 1950s and early 1960s after the Russian Sputnik started the space race, science education in the United States had a rebirth. The focus was placed on learning about science through the doing of science. A number of hands-on, process, and inquiry-based programs were developed with support from the National Science Foundation and other private groups and companies. Known as the "alphabet-soup" programs, they included SCIS (Science Curriculum Improvement Study), SAPA (Science A Process Approach), ESS (Earth Systems Science), IPS (Introductory Physical Science), and BSCS (Biological Sciences Curriculum Study). They were introduced and used in many schools throughout the United States at K–12 levels. Then, in the 1970s through the early 1990s, these programs fell out of favor for a variety of curricular, administrative, and financial reasons. And science teaching returned to the pre-1950s textbook, reading-about-science approach.

The mid-1990s brought the creation of the National Science Education Standards on the heels of the early 1980s A Nation At Risk followed by No Child Left Behind legislation after the turn of the century, and a number of curriculum programs including the American Association for the Advancement of Science Project 2061; the National Science Teacher Association's (NSTA) Scope, Sequence and Coordination; the State Science Frameworks; and more. Thus began the rebirth or return to the doing-of-science approach to science education.

Concurrently, during the early 1990s, the Occupational Safety and Health Administration (OSHA) unveiled and put 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 put general industry employers, including school boards of education, on notice that they must provide for a safe workplace in laboratories to deal with hazardous chemicals and prudent practices.

In addition to OSHA's Laboratory Standard and the national education reports, a third factor that has influenced the direction of science education is the focus on a more diverse student population, including special-needs students. A series of legislative actions, including the Americans With Disabilities Act, required that all students have the opportunities to participate in general education, including science education. Laboratory design and construction, in addition to curriculum and instruction strategies, must attempt in earnest to address these needs.

The fourth factor is the revolution taking place in the cadre of science educators. As in the 1960s, a large group of science educators is reaching retirement age and leaving the profession. With them goes many years of professional experience and knowledge. New teachers with limited experience in laboratory work are taking their places.

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

All of these factors have science teachers asking how they can improve safety in their laboratories and still carry out meaningful activities.

In order to meet some of these challenges, NSTA decided to introduce the column "Scope on Safety" for middle and junior high school science teachers in its middle school journal *Science Scope*. The purpose of the column is simple—provide safety information for middle grade science teachers to help them in addressing the safety issues of hands-on instruction in the laboratory and in the field.

This book is a compendium of those articles starting from the column's inception in February 2003. The articles are based on inquiries from school science teachers nationwide. The topics focus on everyday safety issues that middle grade science teachers and supervisors have to deal with in the doing of science. Each column is written to help the science teacher become aware of legal standards and prudent practices that help make for safe laboratory experiences and also protect both students and teachers. Unfortunately, some architects, building contractors, school administrators, and boards of education members have taken advantage of science teachers on issues such as facility design, occupancy loads, protective equipment, and more. This has happened because science teachers lack the expertise—knowledge and experience—in legal building and safety standards and prudent practices in the laboratory. Unsafe laboratory activities and unsafe laboratory facilities can get science teachers into legal challenges with professional and civil consequences.

The book is divided into four areas. The first is a short introduction to the topics of hands-on science for all students and also protection afforded the science teacher with the introduction of the OSHA Laboratory Standard. The second section addresses safety practices and legal standards with focus on current issues facing science teachers. The third section deals with safety in science instruction. It provides specific information on how to best incorporate safety in various aspects of science teaching. The final section answers questions middle grades teachers asked, through the column, about everyday issues.

Building safe science behaviors begins at the elementary and middle school levels. These practices serve as the guidelines to future laboratory work with many carryovers into everyday life. Safe 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 safe science is a lifelong endeavor, and I hope you will join me in it.

Ken Roy

▽ ACKNOWLEDGMENTS

Special thanks to Ken Roberts, *Science Scope* managing editor, and Inez Fugate Liftig, field editor, for their guidance and direction in the development and operation of the column over the years. Thanks also go to David Beacom, publisher, for his ongoing support and action relative to addressing safety issues in NSTA publications. I could not successfully continue my safety crusade without the love and encouragement from my wife Marisa, my daughters Louise Roy and Lisa Motyl, and my grandson Michael Bride.

▽ ABOUT THE AUTHOR

Kenneth Russell Roy has been a science teacher and administrator for more than 39 years. In addition, he has a large number of experiences as an author and editor with more than 150 published articles and four 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, Connecticut. Roy is also an independent safety consultant/adviser working with professional organizations, school districts, magnet schools, insurance companies, textbook publishers, and other organizations dealing with safety issues.

He earned a bachelor's in science in 1968 and a master's in 1974 from Central Connecticut State University and a PhD 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.

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SECTION I

INTRODUCTION

∇ Safety Is for Everyone

The 1996 National Research Council's *National Science Education Standards* reflects a strong commitment to science education for all students. The Standards reject any situation in which some people are discouraged from pursuing science and excluded from opportunities to learn it. In concert with the Standards, federal laws and regulations mandate equal access and inclusion to the maximum extent possible in the general education curriculum for all students. Two key pieces of legislation include Public Law 94-142 (Education for All Handicapped Children Act), and Public Law 105-17 (The Individuals With Disabilities Education Act—IDEA).

Other federal and state general industry standards for science laboratory safety have been evolving. The regulations began in 1986 with the advent of the Occupational Safety and Health Administration's (OSHA) 29 CFR 1910.1200 (Hazard Communication Standard). It was followed up in 1990 with 29 CFR 1910.1450 (Occupational Exposure to Hazardous Chemicals in Laboratories Standard).

In some ways, the laboratory safety standards may seem to be at odds with science laboratory curriculum expectations in an environment attempting to provide for full inclusion of all students. Clearly, not all students will be able to be fully mainstreamed and may require alternative placement. Careful planning and appropriate accommodations in terms of instructional strategies and assistive technology, however, can provide for equitable access to hands-on science education for all students in a safe learning environment.

Raising the Bar

The challenge for science teachers is to meet the needs of each of their students while maintaining high standards and attempting to raise the educational bar. It is important that special-needs students not be singled out in the classroom. Also, in a team teaching situation (a science teacher teaming with a special education teacher), each teacher must be responsible for all students in the classroom. The science teacher ensures the meeting of curriculum goals, and the special education teacher works to modify and adapt the instructional approaches to those students having IEPs (individual education plans). Although there may be some unique challenges in working with mainstreamed or self-contained students with special-needs in a laboratory situation, teachers should consider alternatives or modifications for providing a safe and effective experience that addresses both special education laws and safety regulation standards.

Special Needs and Safety

For the science teacher, several website resources may prove to be useful. West Virginia University has a website (*www.as.wvu.edu/~scidis*) for teaching science to students with disabilities, which includes lists of teaching strategies by disability. Do-It at the University of Washington in Seattle (*www.washington.edu/doit*) offers workshops, links, and strategies for students and teachers in science. The Parents and Educators Resource Center (*www.schwablearning.org*) offers the Assistive Technology Guide.

In an effort to better meet the science laboratory safety needs for all students, the following strategies are suggested:

- Modify a laboratory activity,
- Secure specialized lab safety and instructional equipment,
- Improve your knowledge level of special needs,
- Eliminate a laboratory activity, or
- Provide an alternative activity for the special-needs student.

Lab safety considerations

- Plan and practice for a barrier-free egress in case of laboratory evacuation.
- Use only plastic or safety glass on all doors or windows in the laboratory.
- Make laboratory doorways wide enough to accommodate wheelchairs or students on crutches.
- Meet minimum net square footage for occupancy loads in consideration of strategically arranged furniture for appropriately sized aisles and numbers of exit doors.
- Provide appropriate safety and instructional equipment including low-profile eyewash/shower, lab station, and reduced height chalk and marker boards.
- Modify utility controls to allow for access to water, gas, and electricity.
- Install computer wires and other cables in a way to prevent tripping hazards.

Instruction safety considerations

- Have special-needs student work with a nonhandicapped student willing to serve in a partner situation or, if necessary, a special education aide.
- Except for modification predetermined by an IEP or PPT (planning and placement team), use consistency in assessment and behavioral expectations of all students.

Although special-needs students often have unique skills or assistive technology to compensate, some activities may need modification. Use a variety of instructional methodologies to compensate for visual and auditory needs

Middle school science teachers can use the "AAA" approach to safety in dealing with special-needs students: Have *awareness* of special-needs students, do an *assessment* for appropriate safety precautions, and take *action* to ensure safety and learning for all students in the science laboratory.

Reference

National Research Council (NRC). 1996. *National Science Education Standards*. Washington, DC: National Academy Press.

▽ BUILD IN SAFETY: OSHA LABORATORY STANDARD

Start With a Strong Foundation

How often have science teachers heard these statements?

- We just don't have enough money in the budget for eyewash stations in your science rooms. Besides, your classrooms are not real science laboratories—don't worry about it!
- I wouldn't be concerned about the ventilation in your laboratory. Smell is part of the territory.
- I don't care if you think that science laboratory was built for 24 students. If I want to put 35 students in there, I will—and you will teach them.

Unfortunately, these types of statements are being made with increased frequency by principals, superintendents, boards of education members, and other decision makers.

Their attitude creates a major stumbling block for science educators in terms of curriculum and instruction and liability. On one hand, teachers are being asked to provide more hands-on activity based science as supported by the National Science Education Standards, with additional impetus coming from the No Child Left Behind legislation and state-level frameworks. On the other hand, they are being told that class size and funding for texts and other support materials are in jeopardy because of increasing enrollments, outdated or inadequate facilities, and declining fiscal support.

The fact is that doing science in a laboratory costs more money and takes more time than reading about science in a classroom. If we are to improve science education by moving in the directions advocated by national reform movements, science educators must take a greater role in helping decision makers better understand and support these initiatives.

One major area that needs to be targeted is laboratory safety. It is one thing to advocate the doing of science. It is a whole other thing to provide a safer laboratory in which these activities take place. To this end, it is critical for science teachers and administrators to become knowledgeable about safety codes and laws. They must be advocates, working with decision makers and helping support them in keeping science laboratories safe for employees and students.

Providing a safe working environment for teachers and students is a serious responsibility for school districts as employers. The foundations for laboratory safety are the Occupational Safety and Health Administration's (OSHA) Occupational Exposure to Hazardous Chemicals in Laboratories or the "Laboratory Standard" for employees working in laboratories, including academic laboratories such as those found in middle schools. OSHA defines the term *laboratory* as "a facility where the laboratory use of hazardous chemicals occurs. It is a workplace where relatively small quantities of hazardous chemicals are used on a non-production basis."

Most public employers under federal OSHA or State Plan OSHA are required to cover laboratory workers (including science teachers) with the Laboratory Standard, 29 CFR 1910.1450 Subpart Z. Science teachers should secure information on which health and safety standards protect them on the job site in their state.

Frame a Strong Safety Program

A strong safety program must to be framed in the design of OSHA's Laboratory Standard. This standard is performance based, meaning that OSHA outlines the basic requirements and then each employer writes a plan tailored to its needs. For example, plans on specific procedures for securing chemicals may vary from district to district, but all plans must contain procedures for purchasing chemicals. The standard also requires that the employer (e.g., board of education) appoint a chemical hygiene officer (CHO) to develop and implement a chemical hygiene plan (CHP).

The basic framework that must be included in the CHP includes the following:

- Scope and Application—This standard covers any employee who is engaged in the laboratory use of hazardous chemicals on a laboratory scale (as opposed to industrial level). Science teachers as employees in middle school are classified under this application if they have a formal laboratory.
- Definitions—This section defines terms such as *action level, employee, laboratory, hazardous chemical,* and *chemical hygiene officer.* These terms are critical points of reference in writing the CHP and standard operating procedures.
- Permissible Exposure Limits (PELs)—Employees are not to be exposed above the permissible exposure limits specified in OSHA's 29 CFR 1910, Subpart Z.
- Employee Exposure Determination—This component requires employees' measurement of exposure to certain chemicals, such as mercury, if the action level or PEL is exceeded, providing a monitoring standard has been established. If monitoring is required, the employee must be notified of the results.
- Chemical Hygiene Plan (CHP) —A written plan must be developed to protect employees from hazards associated with chemicals in the laboratory.
- Employee Information and Training—Employees must be made aware of chemical hazards in the laboratory. The training must be provided at time of initial employment and when new chemicals or hazards are introduced into the workplace. Information must include CHP contents and the Laboratory Standard, PELs and threshold limit values (which define the reasonable level of a chemical substance to which a worker can be exposed with out adverse health effects), exposure signs, and location of related reference material. Training must minimally include methods to detect presence of hazardous chemicals, physical and chemical health hazards in the laboratory and work area, procedures including emergency procedures, work practices, and protective equipment.
- Medical Consultation and Medical Examination—Employer must provide an opportunity for employee medical support and follow-up examinations.

- Hazard Identification—A labeling system such as the National Fire Protection Association labeling codes must be adopted, and material safety data sheets (MSDSs) must be maintained and made available.
- Use of Respirators—When respirators are required as per 29 CFR 1910.134, procedure and equipment must be provided by the employer. In a middle school science lab, the activities should not warrant the need for respirators.
- Recordkeeping—Employers must keep records of exposure monitoring, medical consultation, and examinations of employees.
- Dates—CHP must have been developed and implemented by 31 January 1991.
- Appendices—Nonmandatory recommendations are provided for consideration in the CHP. Although the noted references are not endorsed by OSHA, they address professional expectations and provide specific safety protocols in the laboratory situation. A CHP will be more effective if based on these safety protocols.

Designing the Chemical Hygiene Plan

The CHP components are prescribed by the Laboratory Standard. Each plan must contain the following minimum parts:

1. Operating standards for laboratory operation, which all employees are required to follow.
2. Criteria to determine and implement control measures to reduce employee exposure, such as type of engineering controls (ventilation), use of personal protective equipment (PPE) (goggles), and hygiene practices (hand washing).
3. Requirement that fume hoods and other protective equipment are functioning properly and within specific measures.
4. Provisions for employee information and training, such as frequency and type of safety training and information.
5. Protocols in which laboratory operation requires prior approval from the employer.
6. Provisions for medical consultation and examinations if an employee has a chemical exposure or incident.
7. Designation of personnel responsible for implementation of CHP including achemical hygiene officer (CHO).
8. Provision for additional employee protection when working with particularly hazardous substances such as acid vapors.

These components represent the basic framework for the chemical hygiene plan. Additional items, such as occupancy load and security, can be addressed.

House of Safety

The OSHA Laboratory Standard is the foundation for building an effective laboratory safety program, but safety must be further developed as an ongoing attitude and commitment that never takes a rest. Science teachers and leadership must be advocates for safer science in the laboratory or field. They must work to help educate others to promote and facilitate a safer working environment for employees and students. Hands-on, process, and inquiry science can be fun and a great learning experience for students when designed and built with safety in mind.

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Occupational Safety and Health Administration. 1990. Laboratories [Online]. Available at *www.osha-slc.gov/SLTC/laboratories/index.html* [1999, June 17] and *www.osha.gov/pls/oshaweb/owadisp.show_document?p_table=standards&p_id=10106*

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