Toward High School Stockroom Safety

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Abstract

This discussion will attempt to address both practical and legal issues that confront science educators, in general, and chemistry teachers, in particular. Liabilities of teaching science, collection of material safety data sheets, preparation and maintenance of chemical inventories, suggestions for stockroom organization, and some practical hints for proper disposal of unwanted or unneeded chemicals will be addressed.

Introduction

It is appropriate to clearly state my limitations at the outset of this article. I am not a lawyer, nor have I had any legal training. This article is therefore NOT to be construed as a legal document, nor one that provides legal advice. It is however based upon many years of working in the chemical profession, and following the best safety advice that I can find. Indeed a truly remarkable resource from which I have drawn much sage advice is that of Jack A. Gerlovich's work. Readers of the *Journal of Chemical Education* will recognize Gerlovich as a frequent contributor to science safety columns. His excellent work, The Total Science Safety System (1), has been adopted by the Departments of Public Instruction in several states, including North Carolina, to guide science teachers. Specific references to that work will be provided later in this article.

So, if I'm not a lawyer, why am I writing the article? I've been working with middle school and high school science teachers for over 25 years. I've advised, cleaned and helped clean a number of high school chemistry laboratory stockrooms. I've also supervised a number of college chemistry laboratories over the years. This article is an attempt to pass along some information and tips that I've found helpful through

the years. It is also aimed at the high school chemistry teacher AS AN AID and a source of information. While some aspects of the physical plant will be necessarily addressed, the main thrust is to cite specific areas in which a teacher can make a difference without invoking the building of a new facility. Readers interested in laboratory design are invited to see texts designed for this purpose (2). It is NOT a complete treatise on all the possible legal aspects, but an attempt to provide some suggestions for providing a safer high school chemistry environment. It should also be pointed out that the article is addressed to the high school environment, and not the industrial environment. Discussion of handling and storage of radioactive substances or of biohazards is not included.

Discussion

So why do we worry about chemical stockrooms? Why have a chemical stockroom?

The answer to these questions lies in the fundamental premise that Science in general and Chemistry in particular is a participatory subject. Scientists operate with several basic assumptions. One is that a "way of knowing" science is to do science! The national science education standards (http://nap.edu/readingroom/books/ns es), provide a clear call for active learning on the part of students. Excerpted from the standards is Teaching Standard D:

Teachers of science design and manage learning environments that provide students with the time, space, and resources needed for learning science. In doing this, teachers

- Structure the time available so that students are able to engage in extended investigations.
- Create a setting for student work that is flexible and supportive of science inquiry.
- Ensure a safe working environment.
- Make the available science tools, materials, media, and technological resources accessible to students.
- Identify and use resources outside the school.
- Engage students in designing the learning environment.

While each of the six points of Standard D are worthy of consideration, the safe working environment is most pertinent at the moment. Quoting from the NSES standards:

"Safety is a fundamental concern in all experimental science. Teachers

of science must know and apply the necessary safety regulations in the storage, use, and care of the materials used by students. They adhere to safety rules and guidelines that are established by national organizations such as the American Chemical Society and the Occupational Safety and Health Administration, as well as by local and state regulatory agencies. They work with the school and district to ensure implementation and use of safety guidelines for which they are responsible, such as the presence of safety equipment and an appropriate class size. Teachers also teach students how to engage safely in investigations inside and outside the classroom."
If we attempt much "science inquiry", we obtain the raw materials from someplace, and in a high school chemistry environment, that locus is most frequently the stockroom.

The problem affects a large number of students. The Digest of Education Statistics (Chapter 2. Elementary and Secondary Education, 2000) (http://nces.ed.gov/pubs2001 /digest/dt060.html) indicated that there were, in Fall 1997, 1.45 million students enrolled in 8292 secondary and combined (elementary and secondary) schools in the United States.

Incumbent on any science teacher in the provision of due care (3) are three basic duties:

- The duty to instruct,
- The duty to supervise, and
- The duty to properly maintain equipment

The latter point is most appropriate to our discussion. Chemical stockrooms are, by their very nature, places of non-negligible hazards. Chemical substances, electrical equipment, glassware, containers of compressed gases can all be hazards to a person who is not adequately trained. The *assumption of risk* is a legal principle which has been cited in personal injury suits. This principle applies to those who place themselves in a given situation with a full understanding of the hazards involved. So, while we as teachers have had instruction concerning all the dangers of the laboratory environment, it is probably safe to assume that our students have not. So, for example, having students wander in and out of stockrooms is one practice which we as teachers can easily restrict or eliminate.

One very important principle to note is that our laws regarding personal injury are based upon the principle of the "reasonable person". It should also be noted that state departments of education impose rules which pertain to teachers, so the reasonably prudent teacher should consult with those bodies to learn of applicable rules, and thereby reduce one's exposure to liability. Neither is a one-time "inoculation" sufficient. One should be certain to keep up-to-date on current regulations. One location is maintained by the Lab Safety Supply Company. Among their many links are those to summaries of the Federal Register, where changes in safety regulations are noted monthly.
http://www.lab-safety.com/ (Click on "The Reference Info tab")
Claims that one was using the "Standards" of twenty years ago will hardly provide a defense for today's teacher. While legal implications cause one to behave in certain ways, it is only ethical and moral to provide a safe environment for those around us.

Laboratory safety took a distinct turn in 1970, when the OSH Act established the Occupational Safety and Health Administration (OSHA). This body is charged with the regulation of safety and health of workers. The enormous body of regulations and codes is frequently referred to as 29 CFR 1910 (Title 29, Code of Federal Regulations Part 1910. Part 1910 is the Occupational Safety and Health Standards. The materials are accessible at OSHA. One starting place is:
http://www.osha.gov/pls/oshaweb/
While this article can not and does not present a complete treatment of the manifold safety issues, several major ideas are worth considering in this venue.

Safety Concerns in the stockroom:

1. Ventilation:

There should be good general ventilation to dilute any released materials to levels below their hazard level (4). Standard 1910.106(d)(4)(iv) addresses the exact issue of ventilation:" Every inside storage room shall be provided with either a gravity or a mechanical exhaust ventilation system. Such system shall be designed to provide for a complete change of air within the room at least six times per hour."
The importance of proper ventilation can be seen by an examination of possible effects of vapors. In October of 2001, seven students were

burned at Genoa-Kingston High School (5) after a flash fire involving a demonstration with methanol and chemical salts. A similar case occurred in Michigan (January 2000). Describing the effects of the methanol vapor, "You get a flame-thrower effect," said Steve Weston, a lawyer representing Burton and the student from Lansing. "It jettisons fluid from the bottle, whose opening is pointed like a gun right at these students." The fire marshal in Battle Creek determined the accident could have been prevented if an exhaust system in the room had been used to draw away fumes. While the focus of this paper is on the stockroom, the issue of ventilation is common to both the laboratory and the stockroom. While teachers are rarely given the responsibility of designing a chemical storage area, they should expect that local school administration would endeavor to secure safe working conditions. Should a teacher suspect that unsafe conditions exist, they should communicate those concerns to the appropriate officials in the school. In all such communications, teachers should prepare reports in writing to communicate with the local officials. This provides a paper trail which is less easily forgotten by busy administrators.

2. Chemical storage:

Chemical storage can be viewed from several perspectives: the physical stockroom, the storage cabinets, and shelving.

Labeling: The simplest regulation to follow is to be certain to label all containers. While chemicals from a manufacturer will have adequate container labeling, a critical piece of information to add to each container is the date of receipt. Ink for site-made labels should be waterproof and fade resistant.

Arrangement: Placement of the items on a stockroom shelf should be based upon compatibility--not alphabetical succession. The Flinn Scientific Catalog (among others) contains a very clear description of the storage of chemicals based upon their compatibility. A very good discussion of chemical storage is found at the Flinn site: http://www.flinnsci.com/home_page/sindex.html

While the Flinn catalog contains a pictorial representation of the storage, a web-based listing of organic and inorganic materials (with an alphabetical and storage code) can be found at http://www.sonoma.edu/EHS/HzMt FlinnGd.html. A tip for helping to ensure continuing conformity to such a code is to make a copy of the list (or the picture) and secure the list or picture in the stockroom near the shelves.

Shelving: Shelving falls into the category of ventilation in many respects. Unless the teacher finds him- or herself in the propitious circumstance of replacing all the shelves in a stockroom one may feel that little can be done. For teachers whose plans do not include new laboratory shelving, many companies produce shallow trays (e.g. Rubbermaid) that will provide a modicum of spill prevention. Likewise such shallow trays can--when placed on an appropriate work surface--function effectively when transferring materials from the shelf container to the dispensing container that will be placed in the laboratory. Other considerations arise. Shelving--new or old--needs to be secured to a wall or floor. Additionally shelves with raised lips are helpful in preventing bottles from accidentally being pushed onto the floor--e.g. during a search for another substance. Commercial shelving is available containing raised edges for containing spills, e.g. http://www.labsafety.com/ (galvanized steel).

Large containers: In general, large containers should be avoided by ordering chemicals in the smallest practical size. While larger containers can result in a lower price per gram of a material, it is not generally wise to order a quantity of a chemical that will last for "the next 5 years". When such large quantities cannot be avoided, large containers should be placed on lower shelves--to reduce the possibility of container breakage should it be overturned, and to reduce the possibility that shelves might tumble if they become top-heavy. The temptation to place large containers on the floor should be avoided, lest the containers be kicked or knocked around by those working in the stockroom.

Flammable/Acids/Corrosives storage: Flammable liquids should be stored in accordance with NFPA (National Fire Protection Association) Standards (Flammable and Combustible Liquids) and in safety cabinets that conform to the OSHA/NFPA standards--CFR Standard 1910.106 and NFPA 123) Such cabinets can be found at many sites, including http://www.lab-safety.com/. Appropriate cabinets for Acids and Corrosives can be found at the same URL.

Compressed gases: Compressed gas cylinders are discussed in Standard 1910.101. Should such cylinders be located in a high school stockroom, a prudent person would ensure that such cylinders are secured to a fixed object (e.g. a wall), and not propped in a corner, or against a table.

To assist with an inspection of one's stockroom, at least two very good

chemical storage checklists are available. The more recent listing (6) is found as Appendix 2. This list is a reprinting of the original listing found in *The Science Teacher*(7).

3. Hazardous Chemicals:

Detailed information about chemicals has become more easily accessible. Information on chemicals deemed "hazardous" can be easily found.

The University of Akron maintains a chemical database at: http://ull.chemistry.uakron.edu/erd/

Other databases exist: TOXNET is a group of databases on toxicology, hazardous chemicals, and related areas, and is found at http://toxnet.nlm.nih.gov/

The OSHA web site provides a list of Highly Hazardous Chemicals, Toxics and Reactives (Standard 1926.64 Appendix A)

The National Institute for Occupational Safety and Health provides information on chemicals at http://www.cdc.gov/niosh/npg/npg.ht ml.

The state of New Jersey maintains as a part of its Right-to-Know database, a listing of hazardous materials and fact sheets that are downloadable in PDF format at http://www.state.nj. us/health/eoh/rtkweb/rtkhsfs.htm

In general, high school laboratories should avoid acquiring chemicals that are deemed hazardous. Many activities now exist for the high school level using chemicals that are **not** deemed hazardous. The use of hazardous chemicals when substitutes are available would be imprudent! Some counties have assembled a list of hazardous chemicals that they discourage faculty from using. King County Schools (WA) has established a list of chemicals, in the words of the web site, "whose risks outweigh their chemical utility" http://www.metrokc.gov/ha zwaste/rehab/index.htm

4. Information:

Chemical Hygiene Plans and Material Safety Data Sheets (MSDS)

The passage of the OSH Act of 1970 and the Superfund Amendments and Reauthorization Act (SARA) of 1986 provided some clear mandates to the chemical professional at almost every level. As of January 31, 1991 laboratories engaged in activities that are encompassed within the definition of "laboratory use" must have in place a written Chemical Hygiene Plan (CHP). Online CHPs are available (A few examples are

found at:
http://www.stfrancis.edu/n s/bromer/chp/chp.htm
http://srv2.lycoming.edu/~ne wman/chp/chp.htm
http://research.amnh.org/amc c/CHP.Index.html

The issue of Chemical Hygiene Plans is addressed by another paper in this conference, but it is important to note that a part of this CHP--and an important component of the stockroom--is the library of Material Safety Data Sheets required for chemicals in the inventory. While Chemical suppliers provide MSD sheets with every chemical order, high school stockrooms are frequently filled with chemicals that do not have MSD sheets.
Fortunately, MSD sheets are easily available online. A few sites include:
A site provided by Interactive Learning Paradigms, Inc.
http://www.ilpi.com/msds/ (contains over 80 sites for MSD sheets).
Genium Publishing Company: http://www.genium.com/hazmat/
Iowa State University: http://avogadro.chem.iastate.edu/m sds/
Large Database of MSD information:http://msdssearch.com/
In addition, Interactive Learning Paradigms provides a humorous look at MSDS to attempt to provide students with a better understanding of the MSDS. That resource is found at: http://www.ilpi.com/fun/msds/

5. Signs:

Signs indicating fire extinguishers, fire blankets, eyewashes should all conform to the appropriate OSHA Standard (Standard1910.145--subpart J).
While signs in other parts of the laboratory are sometimes thought to be of greater value in reducing one's exposure to liability, signs in stockrooms can be useful especially if the stockroom is to be shared by more than one teacher--a frequent situation in large high schools. North Carolina Department of Public Instruction (NCDPI) within the past three years provided a low-cost way to have all appropriate signs distributed to high schools.
Clara Stallings of NCDPI designed a set of signs in accordance with the OSHA standards, and had them shrink wrapped (about 20 signs in a package). When schools submitted their safety plans, the school was given a package of the signs. This is, in my opinion, a great way to get the signs into the schools **and** ensure that schools have safety plans in place.

Another important sign NOT to be overlooked is the one that identifies the Health, Fire, and Reactivity of your area. These "diamond" shaped signs--placed in a **prominent outside area**--alert emergency responders to possible hazards.

Contact information should also be posted, so that emergency responders can contact you. You may be there during the day, but if a fire were to occur at 3 a.m, you might **not** be there.

6. Fire protection:

Standard 1910.157 (d4) states: "The employer shall distribute portable fire extinguishers for use by employees on Class B fires so that the travel distance from the Class B hazard area to any extinguisher is 50 feet (15.2 m) or less." Class A and C hazards require that extinguishers be placed within 75 feet or less.

"Almost all flammable and combustible storage areas will require installation of extinguishers with ratings of 20B, 40B, or more to provide adequate extinguishing capacity for gallon bottles of flammable solvents. Since no hand-held carbon dioxide extinguisher on the market has the extinguishing capacity to put out a one-gallon flammable liquid spill fire, it will be necessary to provide fire extinguishers that contain adequate quantities of dry chemical, halogenated agents, or special

form to have ratings of 20B or greater" (8). To debunk the idea that such fires don't occur anymore, a fire in the chemical storeroom of a high school in Wichita, Kansas on 7July2002 caused more than one million dollars in damage according to the first chief. Cause of the fire was unknown due to the extensiveness of the damage. Outside temperature that day reached about 95 degrees (9).

7. First aid:

Here is another place in which the Chemical Hygiene Plan is useful. This document specifies what procedures are to be followed in the event of an accident. Have telephone numbers of local emergency responders and the Poison Control Center posted in the lab stockroom in a clearly visible place. A **pre**-emergency discussion with local emergency responders will be most helpful in deciding good procedures for teachers to follow.

Those personnel will also be able to suggest first aid supplies to be kept on hand.

Many commercial suppliers exist (e.g. http://www.lab-safety.com/) For chemical burns, lavage of the affected areas is the initial treatment. Eyewash stations should be plumbed as opposed to portable bottles. Unless one is certified to render First Aid treatment by some recognized body (e.g. American Red Cross), most first aid should be rendered by trained personnel.

8. Personal Protection Equipment:

The chemical stockroom is a potential source of accidents waiting to happen. Perhaps the first item to note is that protection is easier than treatment. Anticipate possible problems, and avoid them by insisting that all those persons using the stockroom wear appropriate safety equipment. One of the most crucial examples we as teachers set for our students is that of attention to safety. If we are cavalier, they will tend to model their behavior toward safety in a similar fashion. Appropriate clothing is a given. Shoes that cover the feet, aprons or lab coats, and gloves **should be available** and **should be worn**! Eye wear that meets the American National Standards Institute (ANSI)Z87.1a-1991 should be used when one is in the stockroom.

9. Access to the stockroom:

Access to the stockroom should be limited to prevent students or other

untrained personnel from intentionally or unintentionally coming in contact with materials with which they are unfamiliar or unable to safely handle. Gerlovich and Gerard (3) remark concerning the stockroom," The storeroom has periodically been referred to as the "magazine", due to its similarities to military storage areas for ammunition of explosives. Although this analogy may be extreme in classifying all science storerooms, it has application in certain aspects." The danger of having an unauthorized person injured while in the stockroom is only exacerbated by the possibility that a person or persons may take something from the stockroom and use it in an unauthorized setting. A lawsuit, Pittman v. City of Taylor (Michigan), was filed in which a student was injured at home when mixing chemicals furnished by the teacher to construct a rocket. In this case (http://www.ackerman-ackerman.com/articles_01.html) ,described by Gerlovich and Gerard (3) the doctrine of sovereign immunity, a legal principle in which institutions are typically held harmless, was overturned--and a retrial was ordered on the school's liability for furnishing chemicals.

10. Inventory:

A vital part of the Chemical Hygiene Plan is the Inventory. It is also, in my experience, a part that frequently goes untended, quickly becoming out of date.

To a teacher thrust into a situation in which the inventory is suspect, the task of bringing it up to date is daunting. While in larger schools, having all the science teachers assist in updating the record is a given. One suggestion that has proven effective in smaller schools is to have Chemistry teachers from different schools help each other as a good way to show collegiality while accomplishing this task. One hint in maintaining a current inventory is a tip to Occam's Razor. Having a small box with index cards can be a quick way to provide notice of daily changes in inventory--e.g. on 26September, used 100g of $CaCO_3$. Once a week (or as the usage dictates) updating the computerized records from the cards brings the inventory under control. Two items are noteworthy here. Spreadsheets have been widely used to maintain rudimentary stockroom inventories. While extensive stockroom inventory systems exist, many rudimentary systems are available. *The Total Science Safety System* (1) contains a spreadsheet into which has been entered a large number of chemicals, along with other useful information.(Storage Category; CAS #; DOT Hazard Class; NFPA Hazard, Fire and Reactivity codes; suggested personal protection

equipment; exposure limits [PEL and TLV]; and areas for Quantity, Date Received, Expiration date to be completed by the individual teacher. This spreadsheet has the advantage of having approximately 350 chemicals present initially, with any substances not in a given stockroom easily and quickly deleted. The NC Department of Public Instruction--as have a number of other state DPI's -- has adopted the Total Science Safety System (1). One can learn about other Chemical Inventory Systems at:
Commercial systems:
http://research.amnh.org/amc c/CHP.Index.html
http://research.amnh.org/amc c/CHP.Index.html
http://www.acdla bs.com/products/chem_dsn_lab/chemfolder/
Academic systems:
http://www.ehs.ucr.edu/ programs/haz/chem_inv1.htm
A recent addition to the academic systems from Henry Rzepa and colleagues from Imperial College, with the open source theme, is found at:
http://www.ch.ic.ac.uk/csdemo/

In addition to currency, another crucial aspect of this inventory is communication! Be certain that a copy of the inventory is accessible outside the stockroom--perhaps in the school office, so that emergency responders can access the list prior to entering the laboratory should an emergency arise. Another suggestion worth consideration is to contact the local fire department and provide them with a list. They will appreciate the information, and you'll gain an ally in your quest for improved safety at your location.

While the specific data contained in an inventory is subject to some discussion, Stasko(10) offers the following suggestion:" Minimum Inventory data for a meaningful inventory record: Location (building and room) ; Container size; Chemical Abstracts Service (CAS)number" This reference also provides a substantial list of data items that would form a complete inventory record for substances.

One very important consideration occurs when one is preparing an inventory--especially if that inventory is out-of-date. Such a time provides an **excellent** time to ask a vital question: " Do I use this material any more?" If you didn't use it this year, and didn't use it last year, and have no plans to use it next year--throw it out! What better

way to reduce the inventory than to rid oneself of unnecessary substances! What does one do with unnecessary substances? Several answers come to mind. Disposal is one suggestion, and texts exist(11) to provide procedures for converting substances into less harmful forms. One should note that disposal of chemicals should **only** be carried out if the physical condition of the stockroom are satisfactory--proper ventilation via hoods, etc. The Flinn Scientific Catalog also contains many hints on the proper disposal of chemicals. In the many high school stockrooms that I have visited, there are chemicals that no high school teacher should attempt to dispose of. There are also chemicals that cannot be safely disposed of down a sink drain. In such events, a commercial disposal concern should be utilized. While such commercial companies charge a fee to dispose of chemicals, the disposal process should be needed **only once**. Consulting with local college, university, or commercial laboratory concerns should provide a list of concerns. The Environmental Health and Safety group at North Carolina State University has a list of about 20 companies in the North Carolina area that provide disposal services. While this list is primarily of local interest, the point is that universities compile lists of commercial waste disposal companies, and high schools might wish to contact a nearby college or university to inquire about possible lists of companies.

One final note concerning inventory is cogent. It has been my experience that commercial laboratories frequently offer local high schools chemicals that are no longer needed by the company. The answer by the high school teacher should, in all probability, be NO THANK YOU. Obtaining a substance that you don't use--even though the price is right--is no bargain, if that chemical will only sit on the stockroom shelf--and be **another item** to be added to the inventory. When you need to get rid of it, you'll probably have to pay to have it picked up.

Conclusion

Safety, whether in the laboratory, the stockroom, or in the kitchen is best observed constantly. While the threat of litigation from personal injury suits sometimes begins to feel oppressive, it is well to remember that exposure to such liabilities is greatly reduced by the use of "reason". The law expects that we act as reasonably prudent persons would act in the same or similar circumstances.

Armed with the proper equipment, and the proper attitude, teachers can

enjoy the process of science and inquiry, and engage students in the pursuit of a discipline that we find fascinating and intriguing without unnecessary worry of litigation.

Disclaimer

A number of commercial companies and concerns are mentioned in this article. Mention of these companies and or products is not a commercial endorsement of these companies or products.

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Suggestions for Books to have on hand:

1. *Prudent Practices in the Laboratory Handling and Disposal of Chemicals*, National Academy Press, 2101 Constitution Avenue, N.W., Box 285, Washington D.C. 1995
This book can be accessed at: http://books.nap.edu/books/0309052297/html/index.html

2. *Safety in Academic Chemistry Laboratories* (6th Edition), American Chemical Society, 1998, ISBN 0-8412-3259-8

Other Resources:

The National Science Teachers Association maintains a web site accessible for its members. Links for elementary school, middle school, high school, and colleges exist.
http://www.nsta.org/

References:

1. The Total Science Safety System Software, JaKel, Inc. 585 Southfork Drive, Waukee, IA 50263, (both Windows and Macintosh platforms).

2. *Guidelines for Laboratory Design*, 3rd Edition, DiBerardinis, Baum, First, Gatwood, and Seth, Wiley-Interscience,2001 ISBN 0-471-25447-9It.

3. *How to Avoid Being Sued While Teaching Science*, 1986, Jack A. Gerlovich and Timothy F. Gerard. DesMoines IA, JaKel, Inc.

4. *Guidelines for Laboratory Design*, 3rd Edition, DiBerardinis, Baum, First, Gatwood, and Seth, Wiley-Interscience,2001, p257.

5. Beacon News, Chicago, August 8,2002.

6. *Safe Storage of Laboratory Chemicals*, David Pipitone, Editor.2nd Ed.

Wiley-Interscience, 1991,ISBN 0-471-51581-7 (Appendix 2).
7. *The Science Teacher*, 48(2), Feb 1981.
8. *Safe Storage of Laboratory Chemicals*, David Pipitone, Editor.2nd Ed. Wiley-Interscience, 1991, p 62.
9. James Kaufman, The Laboratory Safety Institute, personal communication.
Chemical Inventory Control and Methods, Sharon E. Stasko, in *Handbook of Chemical Health and Safety,* American Chemical Society, 2001, Oxford University Press, p391-397, ISBN 0-8412-3670-4.
11. Armour, M. A, Browne, L.M., and Weir,G.L. , *Hazardous Chemicals: Information and Disposal Guide,* University of Alberta Press, 3rd Edition, 1987.