Integration of Lab Safety Training into the Undergraduate and Graduate Chemical Engineering Programs

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Abstract

The Ralph E. Martin Department of Chemical Engineering is the University of Arkansas' campus-wide leader in the area of laboratory safety training for their undergraduate and graduate students. This paper presents an overview of the laboratory safety training program and how it was integrated into the curriculum. It describes how students are educated about the basics of laboratory health and safety, and it describes the necessity of such training as it pertains to not only OSHA Compliance but also to the ethical obligation to provide a safe and healthy learning and working environment for the faculty and students. This paper defines the process of evaluating necessary training topics using OSHA guidelines.

Introduction

According to Prudent Practices in the Laboratory, a new culture of safety consciousness, accountability, organization and education has developed in the laboratories of the chemical industry, government and academia. So drastic is this new climate toward "safety first" in the laboratory that it could scarcely have been imagined 25 years ago. This new culture of safety consciousness nurtures basic attitudes and habits of prudent behavior in the laboratory so that safety is a valued and inseparable part of all laboratory activity.[1]

In 1997, the Department of Chemical Engineering at the University of Arkansas began the development of laboratory safety training for all undergraduate students participating in the instructional laboratories. Over the past eight years, this program has expanded. Initially, the training consisted of a simple one hour session for undergraduate students, focused primarily on Hazard Communication and the departmental lab rules. Now, the laboratory safety program includes safety seminars held monthly for all chemical engineering graduate students, training for the instructional laboratory teaching assistants and periodic reviews of graduate research projects. By the time the graduate students complete their degree program, they have been exposed to annual training in various areas using the U.S. Department of Labor Occupational Safety and Health Administration guidelines. These areas of training include Fire Prevention, Emergency Action, Storage of Flammable and Combustible Liquids, Proper Storage and Handling of Compressed Gas Cylinders, Proper Storage and Handling of Highly Hazardous Chemicals, Spill Cleanup & Waste Disposal, Portable Fire Extinguishers, Electrical Safety,

Hazard Communication and the Laboratory Standard. The department realizes that there is both an ethical as well as a legal obligation to a high level of commitment to safety and environmental compliance. As a result, all students, whether undergraduate or graduate, come through this department and gain a heightened awareness of such matters to enter the workplace with a safety mindset already firmly established. We believe that this commitment to safety and environmental compliance pays huge dividends for all.

Why Conduct Safety Training?

Our department believes that we have a moral and an ethical obligation to our students and faculty to provide a safe working environment for them. As the American Institute of Chemical Engineers' Code of Ethics states, members must, "hold paramount the safety, health, and welfare of the public and protect the environment in the performance of their professional duties."[2] Simply stated, it would just be wrong to not conduct training for our students concerning the hazards in the laboratories, the means of personal protection against those hazards and proper waste disposal. Is such training really necessary? The answer is a resounding "yes" according to Dr. James A. Kaufman, who is a lab safety expert and the President and C.E.O. of the Laboratory Safety Institute. He is quoted in the May 23, 2005 issue of *Chemical & Engineering News* as saying, "schools and other academic institutions have a 10 to 50 times greater frequency of accidents than does the chemical industry."[3] As educators we must be deliberate in our efforts to shape students' thinking such that safety truly does become an inseparable part of all student laboratory activities.

Besides an ethical and moral obligation, institutions are becoming aware of the liability associated with negligent behavior in the laboratory. Injuries to students in a classroom lab can bring lawsuits for negligence or civil wrong that have the potential for millions in court costs and damages. Placing aside the personal and unnecessary trauma associated with a laboratory accident, the negative public relations to follow can be damaging as well.

Academic institutions, like industrial ones, have been the targets of expensive litigation and exorbitant fees. In 2001, the EPA began its "Colleges and Universities Initiative," which targets higher education institutions with surprise environmental inspections. Learning institutions, particularly in EPA Region 2, have been hit hard with fines in the millions for everything from unlabelled containers to the mishandling of hazardous waste.[4] The maximum civil penalty the EPA can levy for a known violation of the Hazardous Materials Regulations is $27,500.[5] The price of a cavalier attitude toward safety and environmental compliance in terms of public relations, time, and money spent on fines can be very high.

Two Separate Laboratory Safety Programs: Undergraduate vs. Graduate

To develop an effective laboratory safety program, the training needs for the undergraduate should be evaluated separately from the graduate student. Let us consider the differences. First of all, in the undergraduate instructional laboratory, the experiments are usually "tried and true." In other words, the professor or teaching assistant knows approximately what amounts of which chemicals to use to achieve a desired result. In the graduate research lab, this is often not the case. Sometimes, in the quest to discover new knowledge in graduate research, new and

unpredictable hazards are also discovered. The graduate student needs to be equipped through training and education to recognize and evaluate any possible hazards which might arise and be prepared to act in a swift, safe manner.

Another difference is that in the undergraduate lab, it is not uncommon for students to be working with the same chemicals on the same set of experiments, avoiding the complications of inadvertent mixing of incompatible chemicals. In the graduate lab, it is far more likely that each graduate student is working with their own experiment and their own chemicals, which may or may not be compatible with neighboring chemicals. The graduate students need to be trained on chemical incompatibility and proper chemical storage.

Also consider that in the undergraduate laboratory, the professor or teaching assistant will often set up the experiment to the extent that he or she has retrieved the chemicals from storage and is responsible for putting them away at the end of class. The supervisor will deal with the chemical waste resulting from the experiment as well as the changing out of a compressed gas cylinder for the students if one is utilized during the instructional lab. The supervisor or teaching assistant is usually present during the experiments to remind students of laboratory safety precautions and to handle any "mishaps," such as a chemical spill or a broken thermometer. In the graduate research laboratory, the graduate students often work independently. While their professor is available for questions and guidance, often they are not physically present during every experimental run. The graduate student needs to be competent in the areas of proper handling of chemicals, compressed gas cylinders, and hazardous waste, just to name a few. They must be trained to know what to do in the case of a fire or a chemical spill. Training in all of these areas is recommended for the graduate students before they enter the research laboratory.

By and large, the undergraduate instructional laboratory is a more controlled and safer environment. Provided that the professors and teaching assistants are present during lab, have proper safety training in the execution of their duties and provided that all the necessary personal protective equipment is present, functional, and utilized, basic introductory safety training should meet the needs for the undergraduate students.

The Undergraduate Laboratory Safety Training Program

In the Chemical Engineering Department at the University of Arkansas, all undergraduate students enrolled in instructional laboratory classes are required to attend a one hour laboratory safety training given by the safety officer. It is held at the beginning of each semester and no student may participate in their instructional lab class until they have completed this required training. The training is customized to each laboratory and covers the basics of laboratory safety. Training is presented in PowerPoint format. Props and pictures are used in this training to show the students the specific equipment to which the trainer is referring. The information given to the students is in accordance with the OSHA 29 CFR 1910.1200 Hazard Communication Standard along with the OSHA Lab Standard, covered in 29 CFR 1910.1450. Students are informed of the hazards in the lab as well as the methods of protection against those hazards. They are taught to read a NFPA diamond, a chemical label, laboratory signage and a material safety data sheet. Students are taught to detect signs and symptoms of chemical exposure and methods of prevention against exposure. They are trained to use the eyewash and

safety shower and are given training in emergency response in case of a fire or a chemical spill. Environmental compliance as far as proper waste disposal is concerned is also covered in brief. They are trained in the proper use of the personal protective equipment. There is a "no tolerance" policy concerning the use of protective eyewear in the labs; it is required to enter all labs, regardless of the activity in that lab. By introducing the freshmen students to this safety mindset the first week of classes, we are avoiding the development of sloppy laboratory habits and laying a firm foundation for safety.

The teaching assistants in charge of these instructional laboratories receive not only this training, but also attend an additional training session. They are given instruction in the areas of emergency action and response, handling students with acid spills on their clothes, paperwork pertaining to accident victims, fire extinguisher and fire safety training. They tour the lab with the safety officer and are shown where the various safety equipment and personal protective equipment are stored. They are shown the first aid kit, spill control kit, bloodborne pathogens kit, emergency phone numbers, gas detectors and eyewash and safety shower. Bonding and grounding procedures and proper storage and handling of chemicals are reviewed. Teaching assistants also are trained in the proper handling of compressed gas cylinders. Depending on the experience of the teaching assistants, this training can take from one to three hours and is done before the semester begins.

The Graduate Laboratory Safety Training Program

The graduate laboratory safety training program is handled differently from the undergraduate laboratory safety training program. Instead of having only one safety training session at the beginning of each semester as with the undergraduates, the graduate students are required to attend monthly safety training throughout the fall and spring semesters. This training is incorporated into Graduate Seminar and is done in the PowerPoint format. Videos and guest speakers are a nice supplement, if available. Attendance is required for all safety training sessions. At the end of each training session, the graduate students take a quiz which is used for documentation purposes only. Students are graded on attendance. Training topics covered each year are as follows: Emergency Action and Response, Portable Fire Extinguishers and Fire Safety, Safe Storage and Handling of Flammable and Combustible Materials, Safe Storage and Handling of Compressed Gases, Safe Storage and Handling of Highly Hazardous Chemicals, Chemical Spill Cleanup and Hazardous Waste Disposal, Hazard Communication, The Lab Standard, Electrical Safety-Related Work, and Biological Safety. Over the course of two semesters, the graduate students receive training in all of the required safety topics for our department as mandated by OSHA.

Additionally, graduate students working in the laboratories are required to sign up for an individual, one hour review of their project with the safety officer. Students describe their lab protocol, show the safety officer their work space and the chemicals with which they work. Then, the students with the safety officer conduct a hazard analysis. Assessments are made to ensure that their personal protective equipment is adequate for their work. The need for respiratory protection is assessed, and if needed, the paperwork is done, the doctor's appointment is made and the student is fit tested for the appropriate respirator. Students are given the

opportunity to express concerns and/or needs. If necessary, the safety officer makes suggestions to make their work safer.

Where Do We Begin in Developing a Laboratory Safety Training Program?

What has been done in the chemical engineering laboratory can be and should be done in any laboratory setting where chemicals are being stored and/or used. It must be noted that developing an extensive laboratory safety training program can take time. As the old adage goes, "You can only eat the cake a slice at a time." Perseverance is the key!

If you are beginning to put such a program together, the obvious place to start, if it has not already been done, is evaluating the laboratory for hazards and training on Hazard Communication. Once the hazards are identified, it is necessary to either engineer the hazard out of the experiment, modify the experiment to eliminate the hazard or as a last resort, provide the necessary personal protective equipment to protect the student/worker. When hazardous chemicals are present, the hazards are inherent; therefore, the faculty and students must be trained on those hazards and how to protect themselves from those hazards. That is where Hazard Communication comes into effect.

The purpose of the Hazard Communication Standard as stated in 1910.1200(a)(1) "…is to ensure that the hazards of all chemicals produced or imported are evaluated, and that information concerning their hazards is transmitted to employers and employees. This transmittal of information is to be accomplished by means of comprehensive hazard communication programs, which are to include container labeling and other forms of warning, material safety data sheets and employee training."[6] A chemical inventory should be maintained and posted on the door of the laboratory. Material safety data sheets should be obtained for each chemical and chemicals should be labeled. This labeling system should include not only container content, but also hazard information, such as an NFPA label. To view this standard or any of the OSHA standards, go to the OSHA website at www.osha.gov. To find the Hazard Communication standard, look under Safety/Health Topics at that website. There is a direct link to Hazard Communication, which offers guidelines for a model training program.

If the decision is made to expand the safety program beyond Hazard Communication and the basics of lab safety, then it would be necessary to determine what topics should be covered in training. The Table of Contents for the Standard 1910 is a great place to start and it, too, can be found on the OSHA website. Though it is 13 pages of topics by Subpart, it is not difficult to read and assess which topics are pertinent to your facility. Additionally, there are many videos and training programs available through safety suppliers and training institutions covering topics such as compressed gas cylinder safety and spill cleanup. Most learning institutions have an Environmental Health and Safety Department (EH&S) which can be an excellent resource to tap. At the University of Arkansas, the Chemical Engineering Department works closely with the campus EH&S to ensure environmental compliance with hazardous waste. Additionally, they provide portable fire extinguisher training, monthly laboratory inspections and free consultation.

Conclusion

The need for learning institutions to have a laboratory safety program is clear. Every learning institution has an obligation to its students and faculty to provide as safe a working environment as possible and every effort should be made to train students to practice safe science. While the development of such a program can take years, every little bit of progress made could mean an accident avoided. Be challenged today to evaluate the level of safety consciousness in your learning institution and make every effort to ensure that safety is a valued and inseparable part of all laboratory activity. The cost is too great in dollars and good sense not to make strides in this area.

References

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