VIII.10 Hands-On Hydrogen Safety Training

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Project Start Date: October 1, 2010
Project End Date: Project continuation and direction determined annually by DOE

Overall Objectives

- Maintain and update Web-based safety training materials for researchers running hydrogen laboratory experiments
- Teach hands-on safety training to personnel in charge of hydrogen systems

Fiscal Year (FY) 2014 Objectives

Prepare class materials for hands-on safety training

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Safety, Codes and Standards section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

(D) Lack of Hydrogen Knowledge by AHJs (authorities having jurisdiction)

(E) Lack of Hydrogen Training Materials and Facilities for Emergency Responders

Contribution to Achievement of DOE Safety, Codes & Standards Milestones

This project will contribute to achievement of the following DOE milestone from the Hydrogen Safety, Codes and Standards section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan:

- Milestone 5.3: Enhance hydrogen safety training props and deliver classroom curriculum for emergency response training. (4Q, 2012)

FY 2014 Accomplishments

- Completed two modules of classroom training for hands-on hydrogen safety class
- Registered over 300 completions in Web-based hydrogen safety class (www.h2labsafety.org)

INTRODUCTION

LLNL has been conducting hydrogen research for more than 50 years, starting with national security applications and continuing with energy research. For many of these years, LLNL was designated as the pressure safety training facility for the whole DOE complex and other government institutions. Many technicians and researchers visited LLNL to receive training on many aspects of pressure safety, including hydrogen technology, cryogenics, leak detection, and vacuum technology.

This unique training expertise is still available and is now being applied for hydrogen energy research through the development of training materials that may contribute to safe operation within the many institutions working on hydrogen technology.

APPROACH

We are developing a two-pronged approach to hydrogen safety training:

- Researchers conducting laboratory experiments can benefit from basic training on hydrogen and pressure safety. This Web-based training can be completed in ~4 hours.
- Technical personnel in charge of setting up experimental equipment require comprehensive hands-on training on all aspects of hydrogen systems. This extensive training is planned for three full days.

RESULTS

Publicly released in 2010, the Web-based hydrogen safety class (www.h2labsafety.org) reached 300 total completions this year and it is standard training material in many universities, government institutions, and private companies. The class is, however, not well publicized, and targeted advertisement may contribute to more widespread utilization.

In addition to the Web-based fundamentals class, we are developing a hands-on hydrogen safety class for pressure

operators. This comprehensive training will be conducted during a three-day session at LLNL, or at remote institutions if appropriate facilities (classroom, compressed gas supply, and pressure testing laboratory) exist.

The hands-on training class starts with a full day of classroom instruction covering essential topics of pressure system assembly and operation (Table 1). Classroom instruction focuses on identifying hazards, safety precautions, personal protective equipment, and pressurized hydrogen system components and their function. This class greatly expands the descriptions from the online hydrogen safety class, going into detailed operational information about every component in pressure systems, describing their inner functionality, applicability, and recommended use.

Days two and three will be spent in the laboratory for practical application of the classroom information from day one. On day two, students will be handed a safety document and instructed to assemble the pressure system described therein. Students will have to select, inspect and install pressure components, bend tube, install pipe and compression fittings, and assemble the entire system.

On day three this system will be leak checked with a mass spectrometer helium leak detector with a leak rate of no more than 10^{-5} atm-cc/sec helium. The pressure system will then be connected to the data acquisition system and pressure tested remotely at 150% of the maximum allowable working pressure. The last leak test will be conducted using liquid leak detection fluid at the system's maximum operating pressure. Finally, the students will operate the system to reach a desired pressure.

The hands-on class is nearly complete. Two of the five modules for classroom instruction (Table 1) have been completed (Figures 1 and 2). Preliminary versions of the remaining three modules are being completed and reviewed.

TABLE 1. Hands-on safety class structure. Modules 3 and 5 are now complete and preliminary versions of the others are being completed and reviewed.

Modules	
Day 1	**Classroom Teaching**
	Concepts, Hazards Personal Protective Equipment Gas Cylinders CGA fittings supply manifolds flash arrestors Pressure Reducing Regulators Gauges/Pressure Transducers Relief Devices Valves Flash Arrestors Fittings (VCR, bite, NPT, VCO, DIN) Tubing and Piping Quiz
Day 2	**Pressure System Assembly**
	Given a system schematic and description, select components, inspect and install, cut and bend tube, apply various fittings, and assemble full system
Day 3	**System Leak Test and Operation**
	Leak test using a mass spectrometer leak detector; setup data acquisition; conduct remote pressure test; leak test at maximum operating pressure using leak detection fluid; operate system to reach a desired pressure.

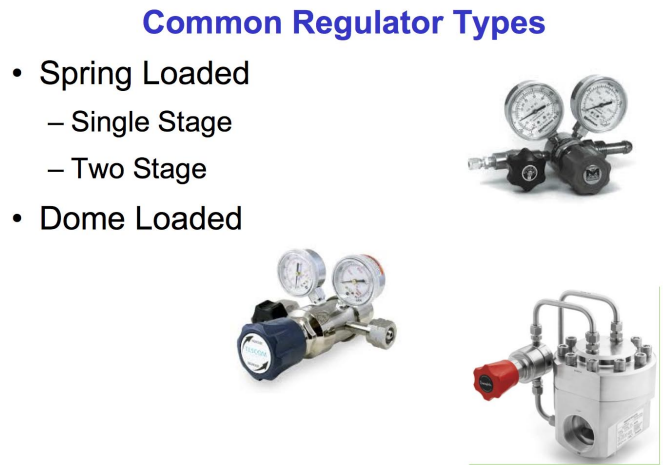

FIGURE 1. Example Page from the "Pressure Reducing Regulators" Module of the Classroom Training Section for the Hands-On Hydrogen Safety Class

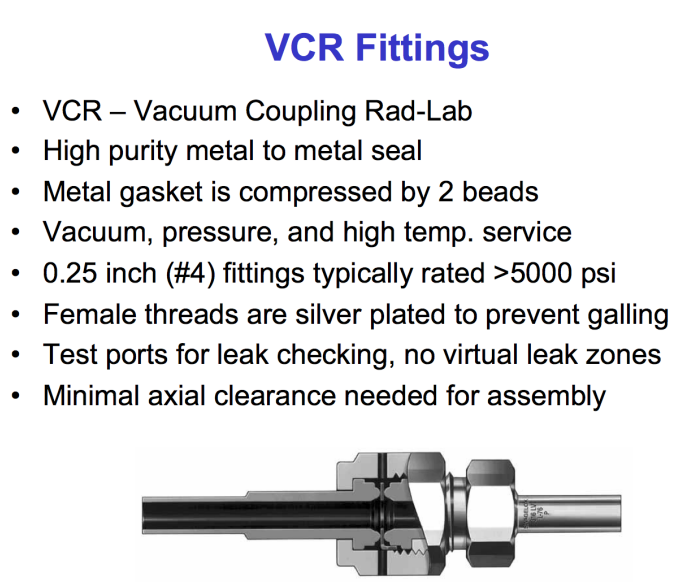

FIGURE 2. Example Page from the "Fittings, Tubing, and Piping" Module of the Classroom Training Section for the Hands-On Hydrogen Safety Class

CONCLUSIONS AND FUTURE DIRECTIONS

LLNL is contributing to safe hydrogen operations by developing instructional materials for researchers and technical operators:

- Laboratory researchers can obtain basic hydrogen safety information from a four-hour Web-based class (free online access at http://www.h2labsafety.org/) addressing hydrogen fundamentals: properties, pressure and cryogenic safety, emergency response, and codes and standards.
- Technical operators in charge of building and testing experimental hydrogen equipment require more in-depth information than provided by the Web-based class. We are therefore preparing a three-day hands-on safety class that presents detailed information for installation, testing, and operation of hydrogen pressurized systems. The hands-on class includes a full day of classroom instruction followed by two days of laboratory work where students assemble, test, and operate a pressure system based on a schematic and component description.

We anticipate completing the hands-on safety class and performing a peer review of the class before releasing it to the public.

FY 2014 PUBLICATIONS/PRESENTATIONS

1. Modeling of sudden hydrogen expansion from cryogenic pressure vessel failure, Petitpas, G. and Aceves, S.M., International Journal of Hydrogen Energy, Vol. 38, pp. 8190-8198, 2013.

2. Web-Based Resources Enhance Hydrogen Safety Knowledge, Weiner, S.C., Fassbender, L.L., Blake, C., Aceves, S.M., Somerday, B.P., and Ruiz, A., International Journal of Hydrogen Energy, Vol. 38, pp. 7583-7593, 2013.

3. Hydrogen Safety Training for Researchers And Technical Personnel, Aceves, S.M., Espinosa-Loza, F., Petitpas, G., Ross, T.O and Switzer, V.A., International Journal of Hydrogen Energy, Vol. 37, pp. 17497-17501, 2012.