

## VIII.3 Hydrogen Safety Tools: Software and Hardware

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Project End Date: Project continuation and  
direction determined annually by DOE

### Objectives

- **Hydrogen Safety Best Practices** - Capture the vast knowledge base of hydrogen experience and make it publicly available to those working with hydrogen and related systems, including those just starting to work with hydrogen.
- **Hydrogen Incident Reporting and Lessons Learned** - Collect information and share lessons learned from hydrogen incidents and near-misses, with the goal of preventing similar incidents from occurring in the future.
- **Hydrogen Fuel Cell Vehicle (FCV) Simulator Prop** - Support the design, construction, commissioning, and training use of a life-size mobile FCV burn prop that is hydrogen-specific.

### Technical Barriers

This project addresses the following technical barriers from the Hydrogen Safety section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- (A) Limited Historical Database
- (B) Proprietary Data
- (I) Lack of Hydrogen Training Facilities for Emergency Responders

### Contribution to Achievement of DOE Safety Milestones

This project will contribute to achievement of the following DOE milestones from the Hydrogen Safety section of the Hydrogen, Fuel Cells and Infrastructure

Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 19:** Publish a Best Practices Handbook. (1Q, 2008)
- **Milestone 20:** Update peer-reviewed Best Practices Handbook. (4Q, 2008)
- **Milestone 22:** Complete first life-size prop for hands-on training of emergency responders. (1Q, 2008)

### Accomplishments

- Hydrogen Safety Best Practices
  - Launched the Web site at <http://www.H2BestPractices.org>.
  - Developed a new section on laboratory safety best practices specific to hydrogen.
- Hydrogen Incident Reporting and Lessons Learned
  - Added 19 new records since the 2007 Annual Merit Review.
  - Conducted technical review of all records by the Hydrogen Safety Panel, with emphasis on fully capturing lessons learned.
  - Improved the incident submission form and the search function capability.
- Hydrogen FCV Simulator Prop
  - Kidde Fire Trainers designed and constructed a mobile FCV simulator prop/trailer to integrate with the emergency responder training curriculum that PNNL and the Volpentest Hazardous Materials Management and Emergency Response (HAMMER) Training and Education Center are developing for the DOE Hydrogen Education Program.
  - Kidde's 60% and 90% design packages were reviewed by vehicle manufacturers (GM, Ford, and Chrysler), energy companies (Chevron and Shell), DOE program managers, firefighters, and the Hydrogen Safety Panel.
  - Kidde provided prop operational and maintenance training to HAMMER and PNNL staff.



### Introduction

PNNL has developed several software and hardware tools to support the Hydrogen Safety Program. This report covers our Hydrogen Safety Best Practices online manual, our Hydrogen Incident Reporting and Lessons

Learned database, and our Hydrogen FCV Simulator Prop. The National Research Council Second Report, Review of the Research Program of the FreedomCAR and Fuel Partnership, states that “The creation of a database on incidents involving hydrogen will be useful in promoting safety.” The report also states that “The committee encourages DOE to continue to develop, publish, and update the best practices document.” The need for hands-on training of emergency responders who may witness or discover a hydrogen incident is well understood by the hydrogen safety community.

## Approach

**Hydrogen Safety Best Practices** - There are many references and resources that deal with the safe use of hydrogen, and our intent was to organize and compile relevant information in an easy-to-use Web-based manual without duplicating existing resources. PNNL teamed with hydrogen safety experts at the Los Alamos National Laboratory and Sandia National Laboratories (SNL), the Hydrogen Safety Panel, and other subject matter experts to compile, draft, review, and annotate best practices tailored to working with hydrogen.

### Hydrogen Incident Reporting and Lessons Learned

**Learned** - The purpose of H2Incidents.org is to facilitate open sharing of lessons learned from hydrogen incidents to help avoid similar incidents in the future. Our approach to this task included encouraging all DOE-funded projects to submit incidents and near-misses and to provide specific lessons learned. We are pursuing the addition of new records by actively seeking news reports on hydrogen incidents and searching existing databases for hydrogen-related safety event records. We contact private-sector companies who experience hydrogen incidents to solicit their permission to publish incident records. We have established and continue to maintain a mechanism for anonymous submission of records. Specific safety event records are linked to the Best Practices online manual to emphasize safe practices for working with hydrogen and avoiding future incidents. Expert review of all incidents and lessons learned is provided by PNNL staff and the Hydrogen Safety Panel.

**Hydrogen FCV Simulator Prop** - PNNL partnered with the Volpentest HAMMER Training and Education Center for this task. Our approach was to leverage Kidde Fire Trainers’ experience with building propane-fueled training props. HAMMER contracted with Kidde to design, construct, and test a one-of-a-kind mobile FCV simulator prop to integrate with the emergency responder training curriculum that we are jointly developing for the DOE Hydrogen Education Program. We plan to test the prop functionality this year with hands-on training exercises for trainers and pilot course participants.

## Results

**Hydrogen Safety Best Practices** - We completed the original sections of the Web site in 2007: Safety Practices (safety culture, safety planning, incident procedures, and communications) and Design and Operations (facility design considerations, storage and piping, operating procedures, and equipment maintenance). The Hydrogen Safety Panel provided initial reviews, followed by a limited public review. The Web site was launched in December 2007, and in early 2008, we completed a new section on laboratory safety that covers hydrogen-related design and operations elements (ventilation, fume hoods, fire protection, explosion protection, cylinder safety, cryogenic liquid, hydride storage and handling, pressure equipment, leak and flame detection, and emergency plans). The hydride storage and handling section was written by SNL and a team of experts from the International Energy Agency’s Hydrogen Implementing Agreement Task 22, Fundamental and Applied Hydrogen Storage Materials Development. The laboratory safety section will be published in September 2008, after it is reviewed by the Hydrogen Safety Panel and any suggested modifications are incorporated.

### Hydrogen Incident Reporting and Lessons Learned

**Learned** - We added 19 new records to H2Incidents.org during the past year. We now have 125 records in the database, and several more are pending approval by the organizations involved. PNNL staff, the Hydrogen Safety Panel, and others provided technical review of all records, with emphasis on fully capturing lessons learned.

**Hydrogen FCV Simulator Prop** - HAMMER staff inspected the new prop at the Kidde facility in New Jersey (see Figure 1), and acceptance tests upon delivery were documented. The prop provides an excellent



FIGURE 1. Hydrogen FCV Simulator Prop

simulation for life-size, hands-on demonstration of an emergency response to a FCV incident, including:

- Safe approach to a FCV (at a 45-degree angle per standard first responder protocol for any vehicle accident).
- Use of gas and flame detectors (e.g., thermal imaging camera).
- Hydrogen venting (sound simulated with high-pressure air) and ignition (with hydrogen).
- Extinguishment of a compartment fire (with propane).
- Extrication techniques (noting the general location of the stainless steel high-pressure hydrogen lines and the orange high-voltage cables).

A safety vulnerability assessment for the prop was conducted by PNNL and HAMMER staff. Engineered or administrative controls will be in place to prevent or mitigate the identified hazards.

### Conclusions and Future Directions

**Hydrogen Safety Best Practices** - Our future work includes resolving the remaining comments from the limited public review (e.g., including more detail on hydrogen properties, adding information on pumps and compressors in hydrogen service, and increasing the visibility of management of change). We will also develop new topical content in conjunction with the Hydrogen Safety Panel, and we will monitor Web site usage and respond to user feedback. We plan to enhance the Web site utility by continuing to link the content to safety event records in the Hydrogen Incident database and by adding photos, graphics, and videos to complement the text.

**Hydrogen Incident Reporting and Lessons Learned** - Our future work will focus on increasing the number of records, partially through identifying additional sources of hydrogen safety event data and lessons learned. We are planning to add a comment submittal feature to every page, and to incorporate graphical software to enable the display of the database contents in graphical format. We will continue to encourage all DOE-funded projects and private-sector organizations to voluntarily submit records of their incidents, and we will monitor Web site usage and respond to user feedback.

**Hydrogen FCV Simulator Prop** - Our future work includes completing and submitting the safety plan and continuing to conduct prop operations at HAMMER. Hands-on prop training will be integrated with the train-the-trainer and pilot courses. We will develop a prop deployment schedule for emergency responder training (jointly with the DOE Hydrogen Education Program) at HAMMER, regional fire training facilities, and possibly other locations.

### FY 2008 Publications/Presentations

1. <http://www.H2Incidents.org>
2. <http://www.H2BestPractices.org>
3. Fassbender, L.L., B. Akers, and C. Cooper, "Introduction to Hydrogen Safety for First Responders", Firehouse Magazine, August 2007, [www.Firehouse.com](http://www.Firehouse.com).
4. Fassbender, L.L., "Status and Plans for Hydrogen Safety Best Practices Online Manual", presentation to the Hydrogen Safety Panel, Las Cruces, NM, December 12, 2007.
5. Fassbender, L.L., "Hydrogen Safety Tools: Software and Hardware", 2008 U.S. DOE Hydrogen Program Annual Merit Review & Peer Evaluation, Arlington, VA, June 12, 2008.
6. Fassbender, L.L., "H<sub>2</sub> Safety Best Practices and H<sub>2</sub> Incidents and Lessons Learned", presentation to the Hydrogen Safety Panel, Golden, CO, June 24, 2008.