
IX.4 Hydrogen Safety Knowledge Tools

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Project End Date: Project continuation and
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Objectives

- **Hydrogen Safety Best Practices** - Capture the vast knowledge base of hydrogen experience and make it publicly available. The best practices online manual is a “living” document that provides guidance for ensuring safety in DOE hydrogen projects, while serving as a model for all hydrogen projects and applications.
- **Hydrogen Incident Reporting and Lessons Learned** - Collect information on hydrogen incidents and near-misses and promote widespread sharing of lessons learned, with the goal of preventing similar incidents from occurring in the future.

Technical Barriers

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

- (A) Limited Historical Database
- (B) Proprietary Data

Contribution to Achievement of DOE Safety, Codes & Standards Milestones

This project will continue to contribute to achievement of DOE Milestone 20 from the Hydrogen Safety section of the HFCIT Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 20:** Update peer-reviewed Best Practices Handbook. (4Q, 2008)

Related milestones in Task 6 (Hydrogen Safety and Incidents) and Task 7 (Best Practices Handbook) have previously been achieved.

Accomplishments

Hydrogen Safety Best Practices

- We added a section on Laboratory Safety that presents: 1) best practices for designers of laboratories where hydrogen will be used and 2) best practices for researchers who will be working with hydrogen in a laboratory setting. The page on hydride storage and handling was developed by a team led by Sandia National Laboratories (SNL).
- We worked with NASA White Sands Test Facility to create a new page on Vacuum Pumps that covers three pump technologies: positive displacement pumps, momentum transfer pumps, and entrapment pumps.
- We worked with the National Renewable Energy Laboratory to develop a new page on Hydrogen Codes and Standards that provides links to three useful codes and standards Web sites: the American National Standards Institute (ANSI) Hydrogen Codes and Standards Portal [1], the DOE Hydrogen Fueling Stations and Telecommunications Permitting Web site [2], and the Hydrogen/Fuel Cells Codes and Standards Matrix [3].

Hydrogen Incident Reporting and Lessons Learned

- Over the past year, we added 15 new safety event records, for a total of 140 records currently in the database.
- With help from the Hydrogen Safety Panel, we improved the completeness and clarity of the lessons learned text for a number of records.
- We improved the incident submission form and the search function capability to make them more user-friendly.



Introduction

PNNL has developed and continues to improve two software tools to support the Hydrogen Safety Program. This report covers our Hydrogen Safety Best Practices online manual (<http://www.H2BestPractices.org>) and our Hydrogen Incident Reporting and Lessons Learned database (<http://www.H2Incidents.org>). 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.”

Approach

Hydrogen Safety Best Practices - There are many references and resources that deal with the safe use of hydrogen, and our intent is 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 (LANL) and SNL, the Hydrogen Safety Panel, and other subject matter experts to compile, draft, review, and annotate best practices tailored to working with hydrogen.

A best practice is a technique or methodology that has reliably led to a desired result. Using best practices is a commitment to utilizing available knowledge and technology to achieve success. Hydrogen-specific best practices are compiled from a variety of references, and links to Web-based resources and actual PDF files are provided on the Web site.

Hydrogen Incident Reporting and Lessons

Learned - The purpose of H2Incidents.org is to facilitate open sharing of lessons learned from hydrogen safety events 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.

Results

Hydrogen Safety Best Practices – PNNL and LANL completed the original sections of the Web site in 2007: Safety Practices (which includes the more management-oriented topics of Safety Culture, Safety Planning, Incident Procedures, and Communications) and Design and Operations (which contains the more engineering-oriented topics of 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 at <http://www.H2BestPractices.org>.

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 was published in September 2008, after thorough review by the Hydrogen Safety Panel. The section contains 24 references, with the main one being National Fire Protection Agency 45, “Standard on Fire Protection for Laboratories Using Chemicals”. This past year, we added more downloadable references, more links to related sites, more links to the incident reporting and lessons learned database, and a new hydrogen flame characteristics video that we developed for the DOE Hydrogen Education Program.

Hydrogen Incident Reporting and Lessons

Learned - We added 15 new records to H2Incidents.org during the past year. We now have 140 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. A comment submittal feature was added to every page, facilitating direct contact with either the content manager or the webmaster. The URL of the page is automatically attached to the subject line of the e-mail message. The Web site is available at <http://www.H2Incidents.org>.

Conclusions and Future Directions

Hydrogen Safety Best Practices - Our future work includes improving existing Web site content as well as drafting new sections. Some of the improvements we are working on include adding more detail on hydrogen properties, increasing the visibility of management of change, and incorporating additional guidance on outdoor storage of hydrogen cylinders.

Ideas for new content have come from the Hydrogen Safety Panel, other national laboratories with whom we frequently collaborate, technical reviewers at the DOE Annual Merit Review, and actual Web site users. For example, it has been suggested that we should consider the needs of end-user communities with less engineering and technological expertise. In response to this suggestion, we plan to add a new section that is focused on technicians and young engineers with limited

or no knowledge of hydrogen properties and behavior. This new section would be more practical and concise, formatted as a series of simple bullets showing what to do and what not to do, and include lots of photos and graphics.

We will continue to monitor Web site usage and respond to user feedback. Users have submitted many requests for additional information and guidance through the Web site's comment submittal feature. We routinely seek guidance from one or more Hydrogen Safety Panel members in crafting our responses to these requests. We also plan to enhance the Web site utility by continuing to link the content to safety event records in the Hydrogen Incident Reporting and Lessons Learned 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 in the database, partially through identifying additional sources of hydrogen safety event data and lessons learned. A significant part of the effort is expended to work with the national laboratories and private-sector firms that experience hydrogen incidents and/or near-misses to help them communicate what happened, what the primary causes and contributing factors were, and most importantly, what lessons were learned by their organizations that could benefit others if they were freely shared. We are planning to incorporate graphical software to enable the display of the database contents in graphical format. We will continue to monitor website usage and respond to user feedback.

We will also continue to encourage all DOE-funded projects and private-sector organizations to voluntarily submit records of their hydrogen incidents and near-misses. Success requires that people use the incident database and not fear negative consequences from reporting and publicizing safety events. We will continue to maintain confidentiality for the organizations that voluntarily submit incident records and will never attribute specific incidents to any national laboratory or private company.

FY 2009 Publications/Presentations

1. Fassbender, L.L., "Safety Knowledge Tools: Recent Work and Forward Plans," 11th Meeting of the Hydrogen Safety Panel, Washington, D.C., December 10, 2008.
2. *H2 Safety Snapshot*, PNNL-SA-63909, Vol. 1, Issue 1, April 2009. (<http://www.hydrogen.energy.gov/newsletter.html>)
3. Fassbender, L.L., "Hydrogen Safety Knowledge Tools," PNNL-SA-65349, 2009 U.S. DOE Hydrogen Program and Vehicle Technologies Program Review and Peer Evaluation, Arlington, VA, May 22, 2009.
4. Fassbender, L.L., "Hydrogen Safety Best Practices," 12th Meeting of the Hydrogen Safety Panel, Vancouver, B.C., June 23, 2009.
5. Weiner, S.C., LL. Fassbender and K.A. Quick, "Using Hydrogen Safety Best Practices and Learning from Safety Events," PNNL-SA-65427, International Conference on Hydrogen Safety, Ajaccio, Corsica, France, September 16–18, 2009 (manuscript submitted).

References

1. ANSI Hydrogen Codes and Standards Portal (<http://hcsp.us/default.aspx>)
2. DOE Hydrogen Fueling Stations and Telecommunications Permitting Website (<http://www.hydrogen.energy.gov/permitting/>)
3. Hydrogen/Fuel Cells Codes and Standards Matrix (<http://fuelcellstandards.com/>)