

IX.8 Hydrogen Safety Panel

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- Edward G. Skolnik, Energetics, Inc. Columbia, MD
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Project Start Date: 2004

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

Objectives

- Provide expertise and guidance to DOE and assist with identifying safety-related technical data gaps, best practices and lessons learned.
- Help DOE integrate safety planning into funded projects to ensure that all projects address and incorporate hydrogen and related safety practices.

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Safety section (3.8) of the Fuel Cell Technologies (FCT) Program Multi-Year Research, Development and Demonstration Plan:

- (A) Limited Historical Database
- (B) Proprietary Data
- (C) Validity of Historical Data
- (D) Liability Issues

- (E) Variation in Standard Practice of Safety Assessments for Components and Energy Systems
- (F) Safety is Not Always Treated as a Continuous Process
- (G) Expense of Data Collection and Maintenance
- (H) Lack of Hydrogen Knowledge by Authorities Having Jurisdiction
- (I) Lack of Hydrogen Training Facilities for Emergency Responders

Contribution to Achievement of DOE Hydrogen Safety Milestones

This project contributes to achievement of the following DOE milestones from the Hydrogen Safety section of the FCT Program Multi-Year Research, Development and Demonstration Plan:

- Milestone 8: Complete investigation of safe refueling protocols for high pressure systems. (1Q, 2012)
- Milestone 20: Update peer-reviewed Best Practices Handbook (4Q, 2008/ongoing)

Related milestones in Task 3 (Failure Modes), Task 5 (Safety of DOE R&D Projects), Task 6 (Hydrogen Safety and Incidents), Task 7 (Best Practices Handbook) and Task 8 (Hydrogen Safety Props) of the above reference have all been achieved with support from the Hydrogen Safety Panel.

Accomplishments

- Conducted two meetings of the Hydrogen Safety Panel: December 8-9, 2009, Energetics, Inc., Washington, D.C.; June 22-24, 2010, Aiken County Economic Development Partnership's Center for Hydrogen Research, Aiken, SC, in conjunction with Savannah River National Laboratory (SRNL).
- Reviewed 50 safety plans since July 1, 2009 for projects in hydrogen storage, fuel cells, production and delivery and manufacturing and updated the DOE/Panel-prepared safety planning guidance resource [1].
- Conducted safety review site visits for two hydrogen storage projects; completed and submitted five safety evaluation reports for site visits previously conducted [2-6]; conducted nine follow-up interviews for previously issued safety evaluation reports and submitted interview reports.
- Provided technical guidance, source material and review for the Hydrogen Incident Reporting and Lessons Learned database (www.h2incidents.org), the Hydrogen Safety Best Practices Web site

(www.h2bestpractices.org) and “Safety Training for Researchers,” an online training tool developed by Lawrence Livermore National Laboratory.



Introduction

Safety is an essential element for realizing the “hydrogen economy” – safe operation in all of its aspects from hydrogen production through storage, distribution and use; from research, development and demonstration to commercialization. As such, safety is given paramount importance in all facets of the research, development, demonstration and deployment work of the DOE FCT Program Office.

Recognizing the nature of the DOE program and the importance of safety planning, the Hydrogen Safety Panel was formed in December 2003 to bring a broad cross-section of expertise from the industrial, government and academic sectors to help ensure the success of the program as a whole. The experience of the Panel resides in industrial hydrogen production and supply, hydrogen research and development and applications, process safety and engineering, materials technology, industrial liability and facility insurance, risk analysis, accident investigation and fire protection. The Panel provides expertise and guidance on safety-related issues and technical data gaps, reviews individual DOE-supported projects and their safety plans and explores ways to bring best practices and lessons learned to broadly benefit the DOE program.

Approach

The Panel strives to raise safety consciousness most directly at the project level. Safety should be driven at the project level by organizational policies and procedures, safety culture and priority. Project safety plans are reviewed in order to encourage thorough and continuous attention to safety aspects of the specific work being conducted. Panel-conducted safety reviews focus on engagement, learning, knowledge-sharing and active discussion of safety practices and lessons learned, rather than as audits or regulatory exercises. Through this approach, DOE and the Hydrogen Safety Panel are trying to achieve safe operation, handling and use of hydrogen and hydrogen systems for all DOE projects.

Results

The Hydrogen Safety Panel was formed in Fiscal Year (FY) 2004 and the first meeting was held in Washington, D.C., December 11-12, 2003. Two meetings of the Panel were held in FY 2010 as noted above. The 13th meeting (Washington, D.C.) included a

topical session on fuel cell applications in the materials handling market with presentations by Air Products, Nuvera Fuel Cells and Plug Power. Panel project work in this application is planned (see Conclusions and Future Directions). The 14th meeting (Aiken, SC) included presentations/discussion with participating organizations in the Hydrogen Storage Engineering Center of Excellence lead by SRNL and facility visits to Bridgestone Firestone and GENCO, both employing fuel cell forklifts for materials handling.

Current Panel membership is noted in Table 1.

TABLE 1. Hydrogen Safety Panel

Richard A. Kallman, Chair	City of Santa Fe Springs, CA
Steven C. Weiner, Program Manager and Panel Coordinator	PNNL
Addison Bain	NASA (ret)
Harold Beeson	NASA White Sands Test Facility
David J. Farese	Air Products and Chemicals, Inc.
William C. Fort	Shell Global Solutions (ret)
Don Frikken	Becht Engineering
Michael Pero	Hydrogen Safety, LLC
Glenn W. Scheffler	GWS Solutions of Tolland, LLC
Andrew J. Sherman	Powdermet Inc.
Ian Sutherland	General Motors
Robert G. Zalosh	Firexplo
Nicholas F. Barilo, Technical Support	PNNL
Edward G. Skolnik, Technical Support	Energetics, Inc.

The Panel conducted safety reviews for the projects noted in Table 2 since the last reporting (safety reviews have been conducted for 41 projects since March 2004). Preliminary reports have been issued for all safety reviews and completed final reports with recommendations are referenced. Final reports were also issued for safety reviews previously conducted [2-6].

The Panel established a follow-up protocol to interview project teams in order to identify actions, findings and conclusions regarding safety review recommendations as one means for measuring the value of this work. Action on report recommendations represents a rich source of safety knowledge that can have broader benefits to others. Table 2 identifies the follow-up interviews that have been conducted and Table 3 summarizes the conclusions for the first eight follow-up interviews.

The Panel concluded that all interviewees have improved the safety aspects of the work they are conducting. Overall, nearly 90% of the

TABLE 2. Hydrogen Project Safety Reviews Since July 1, 2009

Program Area	Project Title	Contractor
Storage	High-Throughput Synthesis and Testing of Porous COF and ZIF Materials for On-Board Vehicular Hydrogen Storage	University of California, Los Angeles
Storage	Development of Improved Composite Pressure Vessels for Hydrogen Storage	Lincoln Composites, Lincoln, NE
Storage	*Effect of Gaseous Impurities on Long-term Thermal Cycling and Aging Properties of Complex Hydrides for Hydrogen Storage	University of Nevada, Reno
Cross-Cutting	*Hydrogen Technology Program: Ammonia Borane Tasks	Purdue University, West Lafayette, IN
Fuel Cells, Storage	*Hydrogen Fuel Cell and Storage Technologies (FCAST) and Solar Hydrogen Generation Research (SHGR) Projects	University of Nevada, Las Vegas
Technology Validation	*California Hydrogen Infrastructure Project Hydrogen Fueling Station	Air Products/ University of California, Irvine
Technology Validation	*Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project	Chevron Technology Venture/Alameda-Contra Costa Transit, Oakland, CA
Fuel Cells	*Fuel Cell Testing	Argonne National Laboratory, Argonne, IL
Fuel Cells	*High Temperature, Low Relative Humidity Membrane Program	University of Central Florida, Cocoa, FL
Production and Delivery	*Investigation of Reaction Networks and Active Sites in Bio-Ethanol Steam Reforming Over Co-Based Catalysts	Ohio State University, Columbus, OH
Production and Delivery	*Water-Gas Shift Reaction via a Single-Stage Low-Temperature Membrane Reactor	Membrane and Process Technology Inc., Pittsburgh, PA

* Follow-up interview and report for previously conducted site visit

recommendations – 58 in number – have been implemented in some manner or are in progress for the set of eight project interviews. A presentation given at the 2010 World Hydrogen Energy Conference noted that “the mechanism used by the Panel for seamless discussion and knowledge sharing at the project level augments the prime responsibility of any organization to ensure the safe conduct of work” [7].

TABLE 3. Categorizing Actions Taken on Report Recommendations - Eight Interviews

Category	Recommendations Implemented	Partial or In Progress	No Action	Total Recommendations
Safety Vulnerability/Mitigation Analysis	13	3	4	20
System/Facility Design Modifications	4	4	1	9
Equipment/Hardware Installation and O&M	5	4	0	9
Safety Documentation	4	4	0	8
Training	1	2	0	3
Housekeeping	4	2	0	6
Emergency Response	6	2	2	10
Total	37	21	7	65

O&M - operation and maintenance

The Hydrogen Safety Panel contributes to PNNL's ongoing work in updating and adding new technical content to two safety knowledge tools, the Hydrogen Incident Reporting and Lessons Learned database (www.h2incidents.org) and the Hydrogen Safety Best Practices Web site (www.h2bestpractices.org). For example, the Panel supported work to add content on laboratory safety aspects for hydrogen storage in cylinders, management of change procedures and additional information on hydrogen properties. Panel members also reviewed technical content for the new feature, the Lessons Learned Corner, in the above mentioned database. A second review of “Safety Training for Researchers,” an online training tool developed by Lawrence Livermore National Laboratory, was completed prior to release by DOE.

Conclusions and Future Directions

Being conscious of the need to use safe practices is a necessary first step for the conduct of all work. The work and approaches taken by the Panel will continue to focus on how safety knowledge, best practices and lessons learned can be brought to bear on the safe conduct of project work.

The Panel will undertake a number of additional initiatives in FY 2011 including:

- Safety plan reviews and safety review site visits for American Recovery and Reinvestment Act fuel cell deployment projects in specialty vehicle, auxiliary

and back-up power, portable and combined heat and power applications.

- Conduct follow-up teleconferences with all project teams for which safety review site visit reports have been issued in order to identify actions taken, findings, conclusions and other learnings.
- Assist PNNL in various technical aspects for future issues of *H2 Safety Snapshot*, a safety bulletin to be published every quarter.
- Consider additional topics for study consistent with the Hydrogen Safety Panel's charter to identify safety-related data and knowledge gaps.

The 15th and 16th meetings of the Hydrogen Safety Panel are planned for April 2011 and September 2011, respectively.

FY 2010 Publications/Presentations

1. Weiner, S.C., "Hydrogen Safety: Supporting DOE's Fuel Cell Technologies Program," PNNL-SA-71796, Energy Facility Contractors Group (EFCOG) Hydrogen Safety Interest Group, Knoxville, TN, April 26, 2010.
2. Weiner, S.C., Fassbender, L.L. and K.A. Quick, "Using Hydrogen Safety Best Practices and Learning from Safety Events," PNNL-SA-70148, International Journal of Hydrogen Energy (Special Edition), 2010.

References

1. "Safety Planning Guidance for Hydrogen and Fuel Cell Projects, April 2010," U.S. Department of Energy, Fuel Cell Technologies Program Office. (<http://www1.eere.energy.gov/hydrogenandfuelcells/codes/oversight.html>)
2. Barilo, N.F., Frikken, D., Skolnik, E.G. and S.C. Weiner, "Safety Evaluation Report: Development of a Novel Efficient Solid-Oxide Hybrid for Co-Generation of Hydrogen and Electricity Using Nearby resources for Local Applications, MSRI, Salt Lake City, UT," PNNL-18570, July 16, 2009.

3. Sherman, A.J., E.G. Skolnik, I. Sutherland and S.C. Weiner, "Safety Evaluation Report: Investigation of Reaction Networks and Active Sites in Bio-Ethanol Steam Reforming Over Co-Based Catalysts, Koffolt Laboratories, Ohio State University, Columbus, OH," PNNL-18718, September 8, 2009.
4. Bain, A., D. Frikken, E.G. Skolnik and S.C. Weiner, "Safety Evaluation Report: Fuel Cell Testing Facility, Argonne National Laboratory, Argonne, IL," PNNL-18719, September 8, 2009.
5. Bain, A., E.G. Skolnik, S.S. Woods and S.C. Weiner, "Lead Research and Development Activity for DOE's High Temperature, Low Relative Humidity Membrane Program, University of Central Florida, Florida Solar Energy Center, Cocoa, FL," PNNL-18927, October 29, 2009.
6. Frikken, D., A.J. Sherman, E.G. Skolnik and S.C. Weiner, "Safety Evaluation Report: Water-Gas Shift Reaction via a Single-Stage Low-Temperature Membrane Reactor, Media and Process Technology, Inc., Pittsburgh and Schenley, PA," PNNL-19090, January 8, 2010.
7. Weiner, S.C., R.A. Kallman and E.G. Skolnik, "Speaking of Safety: Learning from Safety Reviews," PNNL-SA-71062, 18th World Hydrogen Energy Conference, Essen, Germany, May 18, 2010.