

## IX.7 Hydrogen Safety Panel

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- Edward G. Skolnik, Energetics, Inc. Columbia, MD
- Robert G. Zalosh, Firexplo, Worcester, MA

Project Start Date: Fiscal Year 2004  
Project End Date: Project continuation and direction determined annually in consultation with 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 Hydrogen, Fuel Cells and Infrastructure Technologies 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 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 8:** Complete investigation of safe refueling protocols for high pressure systems. (1Q, 2012)
- **Milestone 12:** Complete research needed to fill data gaps on hydrogen properties and behaviors. (2Q, 2010)
- **Milestone 20:** Update peer-reviewed Best Practices Handbook (4Q, 2008)

Related milestones in 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 10–11, 2008, Energetics, Inc., Washington, DC; June 23–25, 2009, Powertech Labs/Ballard Power Systems, Vancouver, BC.
- Conducted seven safety reviews for projects in hydrogen storage, fuel cells and production and delivery and submitted reports to DOE per established protocol.
- Reviewed 50 safety plans since July 1, 2008 for projects in hydrogen storage, fuel cells, production and delivery and manufacturing utilizing DOE/ Panel-prepared safety planning guidance [1].
- Provided technical guidance, source material and review for the Hydrogen Incident Reporting and Lessons Learned Database ([www.h2incidents.org](http://www.h2incidents.org)), the Hydrogen Safety Best Practices Web site ([www.h2bestpractices.org](http://www.h2bestpractices.org)) and *H2 Safety Snapshot*, a new topical safety bulletin [2].

- Completed *Secondary Protection for 70 MPa Fueling, A White Paper from the Hydrogen Safety Panel* with recommendations to DOE regarding fueling a vehicle equipped with a lower-service-pressure fuel tank from a higher-pressure fueling source [3].



## 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 and demonstration of the U.S. DOE Hydrogen, Fuel Cells and Infrastructure Technologies 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 FY 2004 and the first meeting was held in Washington, D.C.,

December 11–12, 2003. The Panel conducted its 11<sup>th</sup> and 12<sup>th</sup> meetings in FY 2009 as noted above. 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	PNNL
Addison Bain	NASA (ret)
Harold Beeson	NASA White Sands Test Facility
David J. Farese	Air Products and Chemicals, Inc.
Don Frikken	Becht Engineering
Michael Pero	Hydrogen Safety, LLC
Harold L. Phillippi	ExxonMobil Research and Engineering
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 (37 such safety reviews have been conducted since March 2004). Preliminary reports have been issued for all these safety reviews and the completed final report with recommendations is referenced in Table 2. Final reports were also issued for safety reviews previously conducted [5,6].

In addition to reviewing safety plans, the Panel commended two additional safety plans to DOE as “good examples” for their reference and use: (1) “Safe Detector System for Hydrogen Leaks” (Intelligent Optical Systems, Inc.) and (2) “Renewable and Logistics Fuels for Fuel Cells (Colorado School of Mines). Six such safety plans have now been commended to DOE for those purposes.

The Panel considered the issue of fueling a vehicle equipped with a lower-service-pressure fuel tank from a higher-pressure fueling source. Recognizing that filling a lower-service-pressure vehicle at a 70 MPa fueling source is likely to result in a catastrophic event, a white paper (*Secondary Protection for 70 MPa Fueling, A White Paper from the Hydrogen Safety Panel*) with recommendations was prepared and submitted to DOE [3].

Several Panel members contributed to a National Fire Protection Association (NFPA) study undertaken in 2008-2009 to identify and evaluate the research needed to support the development of hydrogen safety requirements in NFPA codes and to make recommendations on research programs needed

**TABLE 2.** Hydrogen Project Safety Reviews Since July 1, 2008

Program Area	Project Title	Contractor
Fuel Cells	Fuel Cell Testing at Argonne National Laboratory	Argonne National Laboratory, Argonne, IL
Fuel Cells	Development of a Novel Efficient Solid-Oxide Hybrid for Co-Generation of Hydrogen and Electricity Using Nearby Resources for Local Applications* [4]	Materials and Systems Research, Inc., Salt Lake City, UT
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	Carbon Molecular Sieve Membrane as Reactor/Separator for Water Gas Shift Reaction	Media and Process Technology Inc., Pittsburgh, PA
Production and Delivery	Materials Solutions for Hydrogen Delivery in Pipelines	Secat, Inc., Lexington, KY

\*conducted as both a telephone interview and a site visit

to support these code changes [7]. The Panel also supported the incident investigation of the fire that occurred at the Shell Hydrogen refueling station, White Plains, NY in August 2008 [8].

## 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, practices and lessons learned can be brought to bear on the safe conduct of project work.

In addition to continuing to review project safety plans and conduct safety review site visits for selected projects, the Panel will undertake a number of initiatives including:

- Conduct follow-up teleconferences with project teams for which safety review site visit reports have been issued since 2007 in order to identify actions taken, conclusions, findings and learnings.
- Select topics for future issues of *H2 Safety Snapshot* and serve in an advisory capacity for publication.
- Consider additional topics for study consistent with the Hydrogen Safety Panel's charter to identify safety-related data and knowledge gaps.

The 13<sup>th</sup> and 14<sup>th</sup> meetings of the Hydrogen Safety Panel are planned for December 2009 and June 2010, respectively.

## FY 2009 Publications/Presentations

1. Weiner, S.C. and Barilo, N.F., "Hydrogen Safety Panel: Shaping Safety Awareness and Practice," PNNL-SA-61902, 2008 Mary Kay O'Connor Process Safety Center International Symposium, College Station, TX, October 28–29, 2008. (<http://psc.tamu.edu/symposia/2008/symposium-program>)
2. Hoagland, W., Tchouvelev, A.V., Versloot, N.H.A. and S.C. Weiner, "Technology Spotlight: Task 19 Hydrogen Safety," IEA HIA Newsletter, Vol. 2, No. 2, November 2008. (<http://www.ieahia.org/page.php?s=glance&p=news>)
3. Weiner S.C., "Hydrogen Safety Panel," PNNL-SA-65397, DOE Hydrogen Program and Vehicle Technologies Program Review, Arlington, VA, May 22, 2009. ([http://www1.eere.energy.gov/vehiclesandfuels/resources/proceedings/2009\\_merit\\_review.html](http://www1.eere.energy.gov/vehiclesandfuels/resources/proceedings/2009_merit_review.html))
4. Weiner, S.C., Fassbender, L.L. 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.
5. Zalosh, R.G. and N.F. Barilo, "Wide Area and Distributed Hydrogen Sensors," PNNL-SA-65498, International Conference on Hydrogen Safety, Ajaccio, Corsica, France, September 16–18, 2009.
6. Weiner, S.C., R.A. Kallman and E.G. Skolnik, "Speaking of Safety: Learning from Safety Reviews," PNNL-SA-66356, 18<sup>th</sup> World Hydrogen Energy Conference, Essen, Germany, May 16–21, 2010. (abstract submitted)

## References

1. "Safety Planning Guidance for Hydrogen Projects, November 2007," U.S. Department of Energy, Hydrogen, Fuel Cells & Infrastructure Technologies Program Office. (<http://www1.eere.energy.gov/hydrogenandfuelcells/codes/oversight.html>)
2. *H2 Safety Snapshot*, PNNL-SA-63909, Vol. 1, Issue 1, April 2009. (<http://www.hydrogen.energy.gov/newsletter.html>)
3. *Secondary Protection for 70 MPa Fueling, A White Paper from the Hydrogen Safety Panel*, PNNL-18523, July 6, 2009.
4. 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.
5. Bain, A., Frikken, D., Skolnik, E.G. and S.C. Weiner, "Safety Evaluation Report: Controlled Hydrogen Fleet and Infrastructure Demonstration and Validation Project, Hydrogen Fueling Station, Oakland, CA," PNNL-17685, July 25, 2008.
6. Bain, A., Zalosh, R.G., Skolnik, E.G. and S.C. Weiner, "Safety Evaluation Report: Controlled Hydrogen Fleet and

Infrastructure Demonstration and Validation Project, Shell Hydrogen Refueling Station, Washington, DC,” PNNL-18191, January 27, 2009.

7. “Research Needs in Support of Hydrogen Safety Standards,” Hydrogen Research Advisory Council (R.G. Zalosh, chair), Fire Protection Research Foundation, National Fire Protection Association, 2009.

8. Sell, R.B., “Hydrogen Vehicle and Infrastructure Demonstration and Validation,” DOE Hydrogen Program and Vehicle Technologies Program Review, Arlington, VA, May 20, 2009.