

## VII.10 Hydrogen Safety Panel

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### Subcontractors:

- Addison Bain, NASA (ret), Melbourne, FL
- David J. Farese, Air Products and Chemicals, Inc., Allentown, PA
- Don Frikken, Becht Engineering, St. Louis, MO
- Richard A. Kallman, City of Santa Fe Springs, CA
- Michael Pero, Hydrogen Safety, LLC, Newington, CT
- Andrew J. Sherman, Powdermet Inc., Euclid, OH
- Edward G. Skolnik, Energetics, Inc. Columbia, MD
- R. Rhoads Stephenson, Motor Vehicle Fire Research Institute, La Canada, CA
- Robert G. Zalosh, Firexplo, Worcester, MA

Project Start Date: FY 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 (3.7.4) 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

### Contribution to Achievement of DOE Safety Milestones

This project will contribute to achievement of the following milestones from the Hydrogen Safety section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 12:** Complete research needed to fill data gaps on hydrogen properties and behaviors (2Q, 2010)
- **Milestone 19:** Publish a Best Practices Handbook (1Q, 2008)
- **Milestone 20:** Update peer-reviewed Best Practices Handbook (4Q, 2008)

### Accomplishments

- Conducted two meetings of the Hydrogen Safety Panel: February 27-28, 2007 in Livermore, CA and July 17-18, 2007 in Washington, D.C.
- Conducted four safety review site visits of hydrogen projects and submitted reports to DOE per the established protocol.
- Reviewed 50 safety plans since July 1, 2006 for projects in hydrogen storage, production and delivery and fuel cells.
- Prepared *Safety Planning Guidance for Hydrogen Projects*, April 2007 and recommended adoption by DOE.
- Prepared white paper, *Potential Fire Suppression Agents for Metal Hydride Fires*, and recommended a reactivity and test program to DOE.
- Provided technical guidance and review for the Hydrogen Incident Reporting Database ([www.H2incidents.org](http://www.H2incidents.org)) and the Hydrogen Safety Best Practices website (in preparation).



### 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 DOE's Hydrogen, Fuel Cells and Infrastructure Technologies (HFCIT) 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 (R&D) 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, and open 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. on December 11-12, 2003. The panel conducted its seventh and eighth meetings in FY 2007: February 27-28, 2007 in Livermore, CA and July 17-18, 2007, in Washington, D.C. Current panel membership is noted in Table 1.

Directed by DOE to modify operational aspects of the panel's work, PNNL established a charter, revised protocols for conducting safety reviews and protocols for reviewing reports and meeting information release requirements.

As noted in Table 2, the panel conducted safety reviews since the last reporting (23 since March 2004). Preliminary reports have been submitted for these reviews; the final report for the Lawrence Livermore National Laboratory (LLNL) project review has been submitted to DOE with recommendations for consideration and action; the other final reports are in review.

**TABLE 1.** Hydrogen Safety Panel

Don Frikken, Chair	Becht Engineering
Steven C. Weiner, Coordinator	PNNL
Edward G. Skolnik, Technical Support	Energetics, Inc.
Nicholas F. Barilo, Technical Support	PNNL
Addison Bain	NASA (ret)
Harold Beeson	NASA White Sands
David J. Farese	Air Products and Chemicals, Inc.
Richard A. Kallman	City of Santa Fe Springs, CA
Michael Pero	Hydrogen Safety, LLC
Harold L. Phillippi	ExxonMobil Research and Engineering
Jesse M. Schneider	DaimlerChrysler
Andrew J. Sherman	Powdermet Inc.
R. Rhoads Stephenson	Motor Vehicle Fire Research Institute
Robert G. Zalosh	Firexplo

**TABLE 2.** Hydrogen Project Safety Review Site Visits Since December 1, 2006

Program Area	Project Title	Contractor
Technology Validation	Storage of Hydrogen in Cryogenic-Capable Pressure Vessels	LLNL Livermore, CA
Storage	Effect of Gaseous Impurities on Long-Term Thermal Cycling and Aging Properties of Complex Hydrides	University of Nevada Reno, NV
Technology Validation	Hydrogen Filling Station	University of Nevada Las Vegas, NV
Storage	Hydrogen Technology Program, Ammonia Borane Tasks	Purdue University West Lafayette, IN

- In addition to reviewing safety plans, the panel also commended three safety plans to DOE for use as good example references for other projects. Those plans covered hydrogen project work being conducted at Sandia National Laboratories, the University of Michigan and the University of Central Florida.
- As a revision to the current DOE safety guidance document, the panel prepared *Safety Planning Guidance for Hydrogen Projects, April 2007* and recommended adoption by DOE. The revision incorporates a safety planning checklist, discussion, references for project teams and the DOE requirement for project safety plans.

The panel prepared and submitted a white paper, *Potential Fire Suppression Agents for Metal Hydride Fires*, to DOE. The paper recommends consideration of a three-task reactivity and fire test program aimed at identifying potential fire suppression agents for metal hydrides that may appear to be the most promising candidates to meet the Storage Program goals. This white paper resulted from discussions of fire suppression during several safety review site visits conducted by the panel.

DOE requested that each project respond to a safety questionnaire regarding hydrogen hazards. The panel has initiated a review of ~150 responses to two questions from project teams:

- What hydrogen hazard associated with this project has the potential to result in the worst consequence, and what safety measures are you implementing or plan to implement to deal with this hazard?
- What hydrogen hazard associated with this project is most likely to occur, and what are you doing to reduce the probability that it will happen?

Analysis of these responses will suggest initiatives consistent with the objectives and approaches for panel work as a whole.

## 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.

The ninth and tenth meetings of the Hydrogen Safety Panel are planned for December 2007 and June 2008, respectively.

## FY 2007 Publications/Presentations

1. Weiner, S.C., "Hydrogen Safety Panel," DOE Hydrogen Program Annual Merit Review, Arlington, VA, May 17, 2007. ([http://www.hydrogen.energy.gov/annual\\_review07\\_codes.html](http://www.hydrogen.energy.gov/annual_review07_codes.html))
2. Versloot, N.H.A., Hoagland, W., Tchouvelev, A.V. and Weiner, S.C., IEA-HIA Task 19: An International Collaboration in Hydrogen Safety, Proceedings of the International Hydrogen Energy Conference and Exhibition, Istanbul, Turkey, July 13-15, 2007. (<http://www.pnl.gov/energy/eed/policy-prog/pub.stm>)
3. Weiner, S.C., Kinzey, B.R., Dean, J., Davis, P.B. and Ruiz, A., "Incident Reporting: Learning from Experience," International Conference on Hydrogen Safety, San Sebastian, Spain, September 11-13, 2007.