Hydrogen Safety Panel

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Hydrogen Program Annual Merit Review and Peer Evaluation Meeting
Arlington, VA
May 15, 2012

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An Integrated Approach to Hydrogen and Fuel Cell Safety

US Canada Italy Japan Switzerland France Germany Greece Norway The Netherlands UK European Commission

Hosted by the Istituto Superiore Antincendi (Fire Prevention Institute), Rome, Italy

IEA HIA Task 31 Experts Group

PNNL SC&S Projects

Hydrogen Safety Panel

HAMMER CaFCP Kidde Fire Trainers

The “rescue” at the Sunnyvale (CA) Department of Public Safety

Hydrogen Safety Panel visits Bridgestone Firestone in Graniteville, SC
Overview

Timeline

- First Panel meeting: December 11, 2003
- Continuing

Budget

- Funding received in FY11 = $350K
- Planned funding for FY12 = $500K

Barriers addressed

A. Safety data and information: limited access and availability
C. Safety is not always treated as a continuous process
G. Insufficient technical data to revise standards

Partners

- Panel member organizations (next slide)

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1 Additional FY09 ARRA funds being utilized for Hydrogen Safety Panel work.
2 Technical Plan – Safety, Codes and Standards, Section 3.7.5, Multi-Year Research, Development and Demonstration Plan, 2011.
# Hydrogen Safety Panel

<table>
<thead>
<tr>
<th>Name</th>
<th>Affiliation</th>
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<tr>
<td>Steven Weiner, Program Manager</td>
<td>Pacific Northwest National Laboratory</td>
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<tr>
<td>Richard Kallman, Chair</td>
<td>City of Santa Fe Springs, CA</td>
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<tr>
<td>Addison Bain</td>
<td>NASA (ret)</td>
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<tr>
<td>Nick Barilo</td>
<td>Pacific Northwest National Laboratory</td>
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<td>David Farese</td>
<td>Air Products and Chemicals</td>
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<td>Bill Fort</td>
<td>Shell Global Solutions (ret)</td>
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<td>Don Frikken</td>
<td>Becht Engineering</td>
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<tr>
<td>Aaron Harris</td>
<td>Sandia National Laboratories</td>
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<tr>
<td>Miguel Maes</td>
<td>NASA White Sands Test Facility</td>
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<tr>
<td>Glenn Scheffler</td>
<td>GWS Solutions of Tolland LLC</td>
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<tr>
<td>Andrew Sherman</td>
<td>Powdermet Inc.</td>
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<tr>
<td>Ed Skolnik</td>
<td>Energetics Incorporated</td>
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<tr>
<td>Ian Sutherland</td>
<td>General Motors</td>
</tr>
<tr>
<td>Robert Zalosh</td>
<td>Firexplo</td>
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Objectives

- Provide expertise and recommendations 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.
A Vision

Safety practices, incorporating a wealth of historical experience with new knowledge and insights gained, are in place. Continuous and priority attention is being given to safety to fully support all aspects of hydrogen and fuel cell technologies: research, development and demonstration; design and manufacturing; deployment and operations.
The Project

Organization Safety Policy, Practice and Culture

Safety Plan

R&D, Demonstration, Deployment Work

Safety Evaluation: Site Visit/Telephone Interview

Panel Reviews Safety Plan

Interview as Follow-up to Site Visit

Safety Planning Guidance

Project team

Hydrogen Safety Panel
Accomplishments and Progress
Safety Planning and Site Visit Reviews

Safety Planning
- Reviewed 17 safety plans in the past year.
- When requested by the DOE project officer, the Panel reviews revised safety plans for responsiveness to comments.
- There continues to be a need to reach closure on more safety plans reviewed in the past two years particularly for fuel cell deployment projects.

Safety Evaluation Site Visits
- Five safety evaluation site visit reports issued; four follow-up interviews conducted and reported.
- Successfully implemented content, format and cost/time savings measures for reports
- The Panel addressed: “What have we learned so far from fuel cell deployment projects?”
Accomplishments and Progress
What have we learned so far from fuel cell deployment projects?

- There is a need for a more thorough and integrated approach to project safety planning that involves all parties: hydrogen/fuel cell/equipment suppliers, facility operators, maintenance/repair providers.

- Safety vulnerability analysis needs to consider potential incident scenarios introduced as a result of the fuel cell deployment and equipment operations and exposures, e.g., those involving industrial trucks in warehouse storage, materials handling and truck maintenance/repair areas.

- Third-party certification for equipment such as hydrogen dispensers and fuel cell forklifts is an important consideration for these developing technologies.
Measuring Outcomes from Safety Reviews Categorizing Recommendations and Actions

...covering 14 project safety review site visits

<table>
<thead>
<tr>
<th>Category</th>
<th>Recommendations Implemented</th>
<th>Partial or In Progress</th>
<th>No Action</th>
<th>Total Recommendations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safety Vulnerability/ Mitigation Analysis</td>
<td>23</td>
<td>4</td>
<td>6</td>
<td>33</td>
</tr>
<tr>
<td>System/Facility Design Modifications</td>
<td>8</td>
<td>5</td>
<td>1</td>
<td>14</td>
</tr>
<tr>
<td>Equipment/Hardware Installation and O&amp;M</td>
<td>15</td>
<td>6</td>
<td>1</td>
<td>22</td>
</tr>
<tr>
<td>Safety Documentation</td>
<td>14</td>
<td>7</td>
<td>0</td>
<td>21</td>
</tr>
<tr>
<td>Training</td>
<td>3</td>
<td>3</td>
<td>0</td>
<td>6</td>
</tr>
<tr>
<td>Housekeeping</td>
<td>14</td>
<td>6</td>
<td>1</td>
<td>21</td>
</tr>
<tr>
<td>Emergency Response</td>
<td>8</td>
<td>3</td>
<td>2</td>
<td>13</td>
</tr>
<tr>
<td>Total</td>
<td>85</td>
<td>34</td>
<td>11</td>
<td>130</td>
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</table>

>90% of recommendations voluntarily completed or in progress
Learning from Safety Events
A Statement from the Hydrogen Safety Panel

► Premise

- Hydrogen and fuel cell safety event and equipment failure information and data can serve as a rich and valuable resource if it is systematically collected, analyzed and used to enhance our knowledge.

► Issue

- Sharing information and data that respects the confidentialities and contractual obligations in DOE-funded projects while allowing for the Hydrogen Safety Panel’s review and analysis of such information and data.

► Recommendation

- Identify mechanism(s) for such information sharing and analysis, and facilitate the interaction of the Hydrogen Safety Panel, DOE project management staff and a selected set of contractor project managers for the purpose of establishing the most appropriate mechanism for such work.
Accomplishments and Progress
Strategically Examining the Panel’s Work

As a first step, conducted brainstorming at 16th Panel meeting, San Francisco, CA, September 11, 2011 to support SC&S vision and goals

Hydrogen Safety Panel joined by participating staff from DOE, DOT, Nuvera Fuel Cells, NASA White Sands Test Facility and other DOE national laboratories (LLNL, SNL, SRNL)

“No idea goes unrecorded!” – 75 ideas ranked and collated to include current Panel initiatives worthy of additional emphasis as well as new initiative ideas to consider
<table>
<thead>
<tr>
<th>Current Initiatives</th>
<th>New Initiative Ideas</th>
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<tr>
<td><strong>Safety Planning and Evaluation</strong></td>
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<tr>
<td>Continue safety planning work, safety plan reviews, site visits</td>
<td>Evaluate long-term implementation of site visit recommendations</td>
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<td>Conduct non-DOE project site visits upon request including DOD, NASA facilities</td>
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<td><strong>Safety Events, Best Practices and New Tools</strong></td>
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<tr>
<td>Publish safety event learnings and best practices in technical journals</td>
<td>Establish a mechanism for the Panel to access all reported incidents and near-misses</td>
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<td>Panel as technical contributors for international workshops and initiatives</td>
<td>Expand role of investigating H₂ incidents beyond DOE</td>
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<td>New web-based tools: leak/detection sensors, QRA, maintenance practices, hydrogen properties</td>
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<td><strong>Other</strong></td>
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<td>Tie to C&amp;S work; evaluate and propose code changes</td>
<td>Support AHJs with reviewing hydrogen applications and additional training</td>
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Hydrogen Safety Panel Scorecard...

- 312 safety plans reviewed
  - Revised safety plans responsive to review comments
- 47 safety reviews conducted
- 17 Panel meetings held
  - 17th Meeting, Washington, DC, March 28-29, 2012
- 14 follow-up interviews conducted
  - 90% of safety review recommendations voluntarily completed or in progress
- 6 “good example” safety plans provided
- 6 “white paper” recommendations submitted
- 3 issues of H2 Safety Snapshot published
- 2 incident investigations completed
Collaborations

“to work jointly with others or together especially in an intellectual endeavor”

- International Energy Agency Hydrogen Implementing Agreement Task 31 (Hydrogen Safety)
- International Association for Hydrogen Safety (IA HySafe)
- International Conference on Hydrogen Safety (ICHS)
- Fuel Cell and Hydrogen Energy Association/National Hydrogen and Fuel Cells Codes and Standards Coordinating Committee
- Hydrogen Power Theoretical and Engineering Solutions International Symposium (HYPOTHESIS IX)

- Expanding and enhancing hydrogen safety knowledge
- Sharing and discussing learnings from safety events

Collaborations (continued)

► DOE/NREL Hydrogen Sensor Workshop (June 2011)

► University of California Center for Laboratory Safety Workshop (March 2012)
  - Workshop looked at new, more effective ways to make certain that research is performed safely.
  - Barilo participated in breakout sessions and discussion on hazard assessment and laboratory design.
  - Panel work on incidents, lessons learned and best practices was shared with attendees and potential future collaborations were discussed.
Future Work

Remainder of FY2012

- Complete in-progress work
  - Safety checklist for an outdoor supply system providing hydrogen for an indoor application
  - Water fuel technologies review paper
- Continue to conduct safety evaluation site visits in consultation with DOE
- Complete final report for Panel work on American Recovery and Reinvestment Act (ARRA) fuel cell deployments summarizing findings and conclusions

FY2013

- Continue efforts to promote and ensure safety throughout the FCT project portfolio
- Assist in transitioning safety information and knowledge into safety codes and standards with emphasis on near-term applications
Thank you

- U.S. Department of Energy
  - Fuel Cell Technologies Program (Sunita Satyapal, Program Manager; Antonio Ruiz, Safety Codes and Standards Team Leader)
- All of my colleagues at Pacific Northwest National Laboratory, the Hydrogen Safety Panel and other collaborators
- You, the audience
Technical Back-up Slides
for
FY2012 Merit Review and Peer Evaluation
LEARNING FROM SAFETY EVENTS

A Statement from the Hydrogen Safety Panel

Hydrogen and fuel cell safety event information can serve as a rich and valuable resource if it is systematically collected, analyzed and used to enhance hydrogen safety knowledge. The sharing of lessons learned from safety events can serve to help prevent similar events from happening in the future. Informed analysis of leaks, fires and explosions, and equipment failure and ignition data derived from these safety events can facilitate the development of risk assessment models and help technical experts identify gaps in applicable codes and standards that can be addressed by a variety of means.

The Hydrogen Safety Panel can be a significant asset in realizing the benefits identified above through its role to provide expertise to DOE in identifying safety-related technical data gaps and lessons learned. Knowledgeable analysis through presentations and discussion at Panel meetings continues to be an important means of enhancing the understanding of safety issues for incidents both inside and outside the DOE Fuel Cell Technologies Program. While the confidentiality of contractual obligations inherent in DOE-funded projects are to be fully respected, mechanisms can be established to maintain those confidences while also maintaining a means for the Hydrogen Safety Panel to examine, review and analyze project safety information. Such means should also allow for the Hydrogen Safety Panel’s interaction with project teams to discuss the information being shared.

While the breadth of the entire program portfolio — research, development, demonstration and deployment projects — could be examined for these purposes, the current DOE-funded data collection and analysis work suggests that demonstration and deployment projects may present the most fruitful near-term opportunity for engaging the Hydrogen Safety Panel. Non-DOE industrial and transportation incidents also provide valuable data on equipment and personnel initiated releases and the effectiveness of leak detection and fire/explosion protection measures following the release.

The Hydrogen Safety Panel recommends that the DOE Fuel Cell Technologies Program identify mechanism(s) for such information sharing and analysis, and facilitate the interaction of the Hydrogen Safety Panel, DOE project management staff and a selected set of contractor project managers for the purpose of establishing the most appropriate mechanism for such work.

Respectfully submitted,
The Hydrogen Safety Panel

January 17, 2012
Safety Review Reports and White Papers
2009-2012


<table>
<thead>
<tr>
<th>Safety Review Reports and White Papers 2009-2012 (continued)</th>
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<tbody>
<tr>
<td>15. Skolnik, E.G., Safety Evaluation Follow-up Report for “Investigation of Reaction Networks and Active Sites in Bio-Ethanol Steam Reforming Over Co-Based Catalysts, Koffolt Laboratories, Ohio State University, Columbus, OH,” February 24, 2010.</td>
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Note: Bold font identifies reports and white papers subsequent to the 2011 Annual Merit Review and Peer Evaluation Meeting.


