

# *Hydrogen Safety Panel*

presented by  
**Steven C. Weiner**  
for the  
Hydrogen Program Annual Merit Review and  
Peer Evaluation Meeting

May 11, 2011

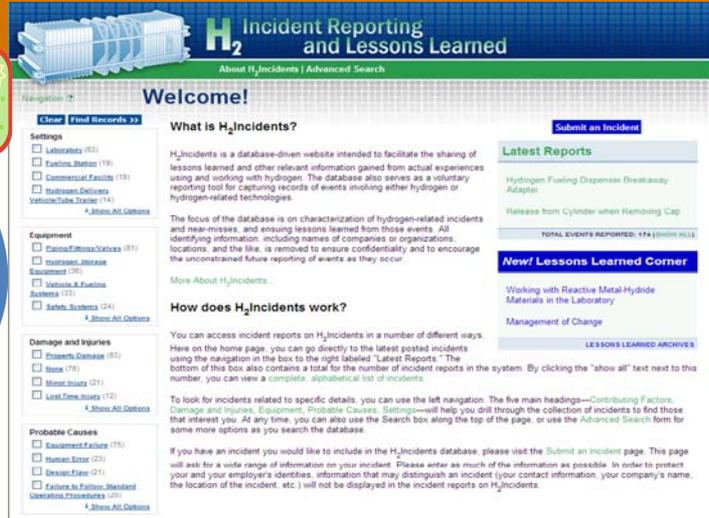
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# An Integrated Approach to Hydrogen and Fuel Cell Safety



2

Incident Reporting/  
Lessons Learned and  
Best Practices



IEA HIA  
Task 31  
Experts  
Group

PNNL  
SC&S and  
ED  
Projects

Hydrogen  
Safety  
Panel

1



Hydrogen  
Safety  
Training

3



# Overview

## Timeline

- First Panel meeting: December 11, 2003
- Continuing

## Budget

- FY10 = \$750K
- FY11 = \$500K<sup>1</sup>

## Barriers addressed<sup>2</sup>

- E. Variation in standard practice of safety assessments for components and energy systems
- F. Safety is not always treated as a continuing process
- G. Expense of data collection and maintenance

## Collaborations

- Energetics Incorporated
- Panel member organizations
- IEA Hydrogen Implementing Agreement Task 31 (Hydrogen Safety)



*Hydrogen Safety Panel visits Bridgestone Firestone in Graniteville, SC*

<sup>1</sup>Additional FY09 ARRA funds being utilized for Hydrogen Safety Panel work.

<sup>2</sup>Hydrogen, Fuel Cells & Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan, October 2007.



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# Hydrogen Safety Panel

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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.



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# *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.*



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# Hallmarks of Our Approach

- ▶ Engage Panel members, OEMs, energy companies, international partners, first responders and other stakeholders in all aspects of our hydrogen safety program
- ▶ Focus interactions with project teams on learning, knowledge sharing and encouragement of thorough, continuous and priority attention to safety

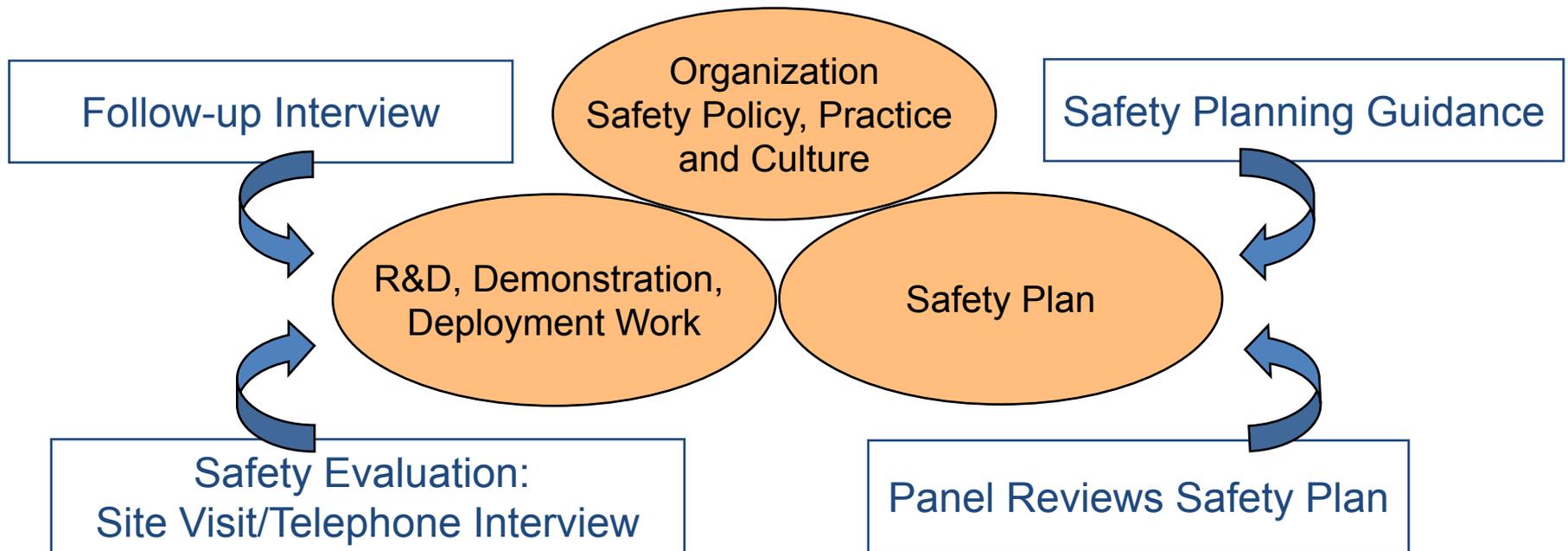


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# Hydrogen Safety Panel Engaging the Project Team

## The Project



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# *From Laboratory to Demonstration to Deployment*



# Hydrogen Safety Panel Meetings Enhance Other Engagements

- ▶ Conducted two meetings of the Hydrogen Safety Panel
  - 14<sup>th</sup> Meeting, Savannah River National Laboratory, Aiken, SC, June 22-24, 2010
    - Discussion with staff in Hydride Storage Engineering Center of Excellence including hydride material performance targets
    - Visit to Bridgestone Firestone and Kimberly-Clark (fuel cell powered forklifts for materials handling)
    - Discussion of cylinder materials issues for HCNG blends
  - 15<sup>th</sup> Meeting, Washington, DC, April 7-8, 2011
    - ARRA project safety reviews and data analysis
    - Learning from safety events for hydrogen fuel cell demonstrations and deployments
  - 16<sup>th</sup> Meeting (planned), International Conference on Hydrogen Safety, San Francisco, CA, September 11, 2011



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# Hydrogen Safety Panel Scorecard...

- ▶ 295 safety plans reviewed
  - *Revised safety plans responsive to review comments*
- ▶ 45 safety reviews conducted
- ▶ 15 Panel meetings held
- ▶ 9 follow-up interviews conducted
  - *90% of safety review recommendations voluntarily completed or in progress*
- ▶ 6 “good example” safety plans provided
- ▶ 5 “white paper” recommendations submitted
- ▶ 3 issues of *H2 Safety Snapshot* published
- ▶ 2 incident investigations completed



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# Technical Accomplishments, Progress and Results – Safety Planning

- ▶ Safety planning work expanded with project interaction
  - Reviewed 60 safety plans in the past year.
  - When requested by the DOE project officer, the Panel reviews revised safety plans for responsiveness to comments.
  - The Panel finds these revisions to be responsive but there is a need to reach closure on more safety plans reviewed in the past year.
  - “*Safety Planning Guidance for Hydrogen and Fuel Cell Projects*” (April 2010)” is being used as a resource by project teams.



# Technical Accomplishments, Progress and Results – Project Safety Reviews

- ▶ Safety reviews are focused on engagement, learning and discussion with project teams
  - 7 safety reviews conducted since April 2010 including two ARRA FC-powered forklift materials handling projects:
    - Sysco Food Services of Houston, Inc.
    - Nuvera Fuel Cells/H-E-B, San Antonio, TX
  - Site visits result in a substantial number of recommendations to DOE and the project teams: 48 recommendations in four reports issued since October 2010.
  - Hydrogen Safety Panel conducts teleconference follow-up interviews with project teams to discuss report recommendations.
    - Identify actions taken and conclusions reached, measure impact and validate approach



# Measuring Outcomes from Safety Reviews Categorizing Recommendations and Actions...

**...covering nine project safety reviews**

Category	Recommendations Implemented	Partial or In Progress	No Action	Total Recommendations
Safety Vulnerability/ Mitigation Analysis	14	3	5	22
System/Facility Design Modifications	4	4	1	9
Equipment/Hardware Installation and O&M	9	4	0	13
Safety Documentation	5	6	0	11
Training	1	3	0	4
Housekeeping	5	2	0	7
Emergency Response	6	3	2	11
Total	44	25	8	77

90% of recommendations voluntarily completed or in progress



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# Technical Accomplishments, Progress and Results – Review of NREL Energy Systems Integration Facility

- ▶ Hydrogen Safety Panel invited to participate in 30% design review of new NREL facility (September 21, 2010)
  - Hydrogen Technologies and Systems Center, e.g.,
    - Fuel cell and electrolysis R&D including grid integration
    - Component R&D at pressures up to 700 bar
    - High pressure testing bays
  - Center for Electricity, Resources and Building Systems, e.g.,
    - High Voltage/High Current Laboratory
- ▶ Topical Discussion
  - Electrical classification
  - Ventilation design; explosion venting for hydrogen
  - Hydrogen supply and usage rates over time

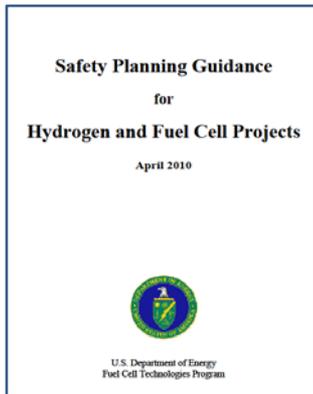
*“Good team asking the right questions. Impressed with the people and interaction.” – Hydrogen Safety Panel member*

*“Based upon the benefits we reaped from your team’s involvement, I would strongly recommend your team’s involvement to other facilities.” – NREL EH&S*



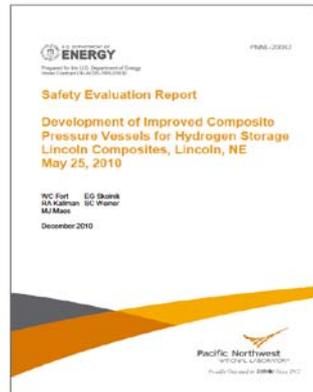
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# Safety Reviews Help Guide



## Issue Topics

- Safety knowledge databases
- Handling compressed H<sub>2</sub> gas cylinders
- Identifying safety vulnerabilities
- Ventilation (planned)



Vol. 2, Issue 1, Nov. 2010

### HANDLING COMPRESSED HYDROGEN GAS CYLINDERS

Proper training and procedures are key elements of a safe work environment. Compressed gas cylinders, as with other equipment, pose risks if they are not handled properly.

This issue outlines good practices for the safe handling of gas cylinders. The information will help you create a safer environment by minimizing the likelihood of an accident involving a gas cylinder.

#### Personnel Handling Gas Cylinders

*DO* ensure that cylinders are handled only by trained personnel knowledgeable in the handling and use of pressurized flammable gas. The training should cover compressed gas safety, fittings and connections, and how to safely attach a regulator to the top of a cylinder. For compressed hydrogen, the specific nature and hazards associated with hydrogen should also be discussed.

*DON'T* allow untrained personnel to handle gas cylinders.

#### Transporting, Receiving and Staging Cylinders

*DO* ensure that gases are delivered with a valve protection cap on the top of each cylinder. This protective cap should remain until the cylinder is delivered to its point of use, where a regulator is attached. See related lessons learned at [www.h2incidents.org/incident.asp?inc=266](http://www.h2incidents.org/incident.asp?inc=266).

*DON'T* accept any cylinder that is unmarked or has conflicting markings or labels regarding its contents. Never rely on the color of the cylinder to identify the contents. If there is any conflict or doubt concerning the contents, do not use the cylinder. Return it to the vendor.

*DO* use a cylinder cart with a restraining device to move large cylinders and specially designed cylinder holders to carry small cylinders.

*DON'T* transport a cylinder of compressed gases with a regulator attached to it.

*DO* secure cylinders from tipping over by using holders or restraints designed for such service. Double cylinder restraints (high and low) should be installed in a seismically active area.

*DON'T* pick up a cylinder by its cap.

For more information on compressed hydrogen gas cylinders, see the Pressure Safety module of "Hydrogen Safety Training for Researchers", a Web-based class developed by Lawrence Livermore National Laboratory. This module will assist you in recognizing general pressure system safety issues and introduce considerations specific to system components exposed to hydrogen.

[www.h2lab.safety.org](http://www.h2lab.safety.org)

#### References for Handling Compressed Gas Cylinders

**H2 Safety Best Practices**  
[www.h2bestpractices.org/lab\\_safety/lab\\_design/cylinder\\_safety.asp](http://www.h2bestpractices.org/lab_safety/lab_design/cylinder_safety.asp)

**Air Products Safetygram #10, Handling, Storage, and Use of Compressed Gas Cylinders**  
[www.airproducts.com/nr/rdonlyres/9d35ee4f-b86f-42c6-9087-6125c14123a0/safetygram10.pdf](http://www.airproducts.com/nr/rdonlyres/9d35ee4f-b86f-42c6-9087-6125c14123a0/safetygram10.pdf)

**Matheson Tri-Gas, Safe Handling of Compressed Gases in the Laboratory and Plant**  
[www.mathesonigas.com/pdfs/TCenter/SpecGas&EquipmentBrochures/Safe%20Handling%20of%20Compressed%20Gases.pdf](http://www.mathesonigas.com/pdfs/TCenter/SpecGas&EquipmentBrochures/Safe%20Handling%20of%20Compressed%20Gases.pdf)

**Matheson Tri-Gas, Guide to Regulators**  
[www.mathesonigas.com/pdfs/TCenter/SpecGas&EquipmentBrochures/Guide%20to%20Regulators.pdf](http://www.mathesonigas.com/pdfs/TCenter/SpecGas&EquipmentBrochures/Guide%20to%20Regulators.pdf)



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# *One View of a Critical Need Safety Event Data Collection, Analysis and Use*

- ▶ Safety event leak and failure data from demonstration and deployment projects can serve as a rich and valuable resource if systematically collected, analyzed and used
  - More fully identify lessons learned
  - Develop quantitative risk assessment models
  - Identify gaps in applicable codes and standards
- ▶ Issues surrounding proprietary and confidential information are real and to be respected, but they are solvable!
- ▶ Some initiatives including international efforts are in the early stages of development.
- ▶ The Hydrogen Safety Panel can be a resource to effectively contribute to this work.

*See additional discussion in “Supplemental Slides – Responses to 2010 Reviewers’ Comments”*



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# Future Work

## ▶ Remainder of FY2011

- American Recovery and Reinvestment Act (ARRA) fuel cell deployments
  - Complete review of safety plans and conduct safety review site visits
- Continue to review all project safety plans, complete site visit reports, conduct safety reviews as identified and provide technical support for safety knowledge tools (including *H2 Safety Snapshot*)
- Propose FY2012 Annual Operating Plan (AOP) to DOE
  - Prepare first draft by late-June
  - Consider all feedback received accordingly
  - Panel consideration of new initiatives

## ▶ FY2012

- Complete ARRA safety review site visits and final report summarizing findings and conclusions
- Implement AOP, supporting safety plan reviews, site visit safety evaluations, *H2 Safety Snapshot*, continued improvements to “H2incidents.org” and “H2bestpractices.org”, new initiatives



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# Thank you...

- ▶ U.S. Department of Energy
  - Fuel Cell Technologies Program (Sunita Satyapal, Program Manager; Antonio Ruiz, Safety Codes and Standards Team Leader)
- ▶ Colleagues at Pacific Northwest National Laboratory, the Hydrogen Safety Panel and other collaborators



## Contributors

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- ▶ You, the audience