

IX.5 Hydrogen Safety

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Objectives

- Draft a comprehensive safety plan to be completed in collaboration with industry. The plan will initiate the research necessary to fill safety information gaps and detail activities of the Hydrogen Safety Review Panel (HSRP), formed in 2004.
- Continue to provide expertise and guidance to the DOE program and assist with identifying areas of additional research.
- Integrate safety procedures into all DOE project funding procurements. This will ensure that all projects that involve the production, handling, storage, and use of hydrogen incorporate project safety requirements into the procurements by 2005.
- Publish a handbook of Best Management Practices for Safety by 2007. The Handbook will be a "living" document that will provide guidance for ensuring safety in future hydrogen endeavors.
- Establish a National Hydrogen Safety Training activity for preparing emergency responders, code inspection officials and others for a future hydrogen economy.
- Build public confidence that hydrogen can be as safe as the fuels in widespread use today.

Technical Barriers

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

- A. Limited Historical Database for Components
- B. Proprietary Data
- C. Validation 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 Continuing 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

Approach

- Continue DOE project reviews using the panel of hydrogen safety experts, focusing on engagement, learning and discussion rather than investigatory or "auditing" exercises.
- Support the compilation of critical data and information/findings needed to ensure safety is maintained in all aspects of hydrogen production and use.
- Facilitate and participate in collaborative information-sharing efforts to develop safe guidelines and methodologies for hydrogen and fuel cell technologies.
- Support education/training for emergency first responders, code officials, and the general public to ensure safe hydrogen use.

Accomplishments

- Completed eight site reviews of DOE hydrogen projects and initiated a project telephone safety interview technique, in addition to conducting eleven safety plan reviews and two official meetings of the HSRP.
- Proposed a number of suggestions/recommendations made to DOE for improving project safety that were embraced by the principal investigators.
- Developed and implemented a safety questionnaire template to assess project-specific safety vulnerabilities, risk mitigation approaches and accident scenarios.
- Received and reviewed 175 safety questionnaires as a part of the 2005 DOE Hydrogen Program Review.
- Developed first-tier hydrogen safety curriculum for the emergency response training program at HAMMER (Hazardous Materials Management and Emergency); held two pilot classes with a total of about 60 attendees.
- Participated in two working meetings of the International Energy Agency Hydrogen Implementing Agreement, Hydrogen Safety task.
- Published and presented four peer-reviewed papers on hydrogen safety.

Future Directions

- As a result of the Hydrogen Safety Program, safety plans are now required for all hydrogen projects under all new DOE HFCIT contracts. Numerous HSRP reviews of future safety plan submissions are therefore anticipated in the coming months.
- Select some number (TBD) of new projects for in-person site reviews by the HSRP; current plans call for 15 site visits per year.
- Review all project safety questionnaires submitted for the 2006 DOE Hydrogen Program Review as a means of assessing safety vulnerabilities, risk mitigation approaches and accident scenarios; and identifying and prioritizing project selection for telephone interviews and site visit safety reviews.
- Finalize design of the first life-size training prop at the HAMMER site and initiate construction, and develop the second tier of training curricula.
- Continue widespread sharing of data and information related to hydrogen safety through participation in international meetings, producing publications, and initial preparation of a safety best practices document.

Introduction

Safe practices in the production, storage, distribution, and use of hydrogen are essential components of a hydrogen economy. Like all fuels, hydrogen can be handled and used safely with appropriate sensing, handling, and engineering measures. Hydrogen's use as a fuel is still a relatively new endeavor, however, with the consequence that proper methods of handling, storage, transport and use are often not well understood across the various communities either participating in or impacted by its development and demonstration.

The aims of this project include: ensuring safety across the wide-ranging DOE program as it investigates and develops technologies for enabling the use of hydrogen as a fuel; contributing to national training needs for emergency responders related to hydrogen use and the future hydrogen economy; providing a comprehensive database of information on hydrogen and hydrogen safety; and participating in international collaborations that maximize safety impacts through sharing of relevant information, results and experience.

Ultimately, the project goal is to build public confidence that hydrogen can be as safe as the fuels in widespread use today. Without such confidence, the hydrogen economy cannot succeed.

Approach

The first step in ensuring safety of the future hydrogen economy is ensuring safety in DOE's program. The HSRP takes seriously its commitment to this objective. The HSRP conducts detailed reviews of safety plans and projects, identifying potential hazards and suggesting best practices whenever appropriate. Multiple members participate in every such review to ensure that a diversity of perspectives is achieved. Members of the HSRP together comprise some of the most extensive hydrogen safety expertise in existence, and the Safety Program is making the most of their contribution.

Extensive external input is also sought to help maximize the value of safety activities. Because of the broad potential applicability of hydrogen and

related technologies, expertise relevant to ensuring safe operations of these technologies is similarly wide-ranging. This expertise is solicited whenever appropriate. The training curricula at HAMMER, for example, are compiled from a broad set of sources that not only includes DOE but also a number of outside organizations. Feedback is then continually collected from the emergency response community and other relevant personnel to ensure that the Safety Program offers the skills and knowledge needed most.

Communication is also a principal emphasis for maximizing impact of Safety Program activities. All of the data and information obtained (of a non-confidential nature), and recommendations developed through activities of the HSRP, for example, are to be made widely available through public presentations and an eventual release of a Hydrogen Safety Best Practices document and database. Training, testing and verification activities to be undertaken at the HAMMER site will be documented and provided through various media to make them available to the greatest number of recipients possible, including those unable to travel to the HAMMER site. Open sharing of information is the primary function of collaboration with both domestic and international organizations. Achieving the stated safety intentions requires a high degree of communication in all Safety Program activities.

Results

The Safety Program was able to achieve a number of accomplishments in different areas despite funding limitations introduced by FY 2005 budget earmarks. A few planned activities were either reduced in scope or eliminated altogether, but the Safety Program has still yielded significant progress towards achieving its objectives. Results are reported by task area below.

Hydrogen Safety Review Panel

The Hydrogen Safety Review Panel, formed in FY 2004, is supported by Pacific Northwest National Laboratory and Energetics, Inc. The Panel conducted two meetings in FY 2005: November 4, 2004, in Richland, WA and June 16-17, 2005, in Washington, DC.

In order to bring safety-related expertise to bear for the broad benefit of the Hydrogen Program, the Panel has undertaken initiatives that continue efforts begun in FY 2004 as well as new ones in FY 2005. Five safety review site visits have been conducted in FY 2005 through June 30, 2005, (see Table 1) and four site visit reports with findings and recommendations have been submitted to DOE for consideration and action. Two recent publications/presentations noted later provide an analysis and dissemination of findings with particular emphasis on the design and assembly of equipment, standard operating procedures, equipment maintenance and hydrogen storage materials.

A telephone safety interview technique was developed by the Panel to more broadly and efficiently identify projects for which a site visit is warranted. Questions focused on five topic areas to help a Panel team interview project staff to: discuss quality of the safety plan, the potential for hydrogen explosion/fire, prior experience with hydrogen, reportable hydrogen incidents, and other potential safety hazards. Three telephone interviews were conducted in May/June to beta test the technique and one project has been identified for a site visit review.

In conjunction with the 2005 Hydrogen Program Review, the Panel developed a safety questionnaire template to assess project-specific safety vulnerabilities, risk mitigation approaches and accident scenarios. The template asked the following questions:

- What is the most significant hydrogen hazard associated with this project?
- What are you doing to deal with this hazard? Please list pertinent safety measures you are implementing and/or plan to implement.
- What is the most likely hydrogen accident scenario associated with this project?
- What are you doing to reduce the risk associated with this most likely accident scenario?
- What other serious safety concerns do you have in working on this project?
- Do you have significant safety concerns that you would like to discuss with the Safety Panel? Please explain.

Table 1. Hydrogen Project Safety Review Site Visits in FY 2005

Program Area	Project Title	Contractor
Fuel Cells	*Cost-Effective High-Performance Advanced Reforming Module (CHARM)	Nuvera Fuel Cells Cambridge, MA
Fuel Cells	*Novel Non-precious Metals for PEMFC	University of South Carolina Columbia, SC
Storage	*Standardized Testing Program for Chemical Hydride and Carbon Storage Materials	Southwest Research Institute San Antonio, TX
Storage	*Fuel Cell and Hydrogen Research	University of South Florida Tampa, FL
Technology Validation	*Hydrogen Technology Park	DTE, Southfield, MI
Technology Validation	Microgrid and Hydrogen Fueling Facility	NextEnergy, Detroit, MI

* Project review site visits completed as of June 30, 2005

The Panel received 175 responses and will form teams to review the responses, and will identify and prioritize projects for additional telephone interviews and site visit safety reviews.

Panel teams reviewed 11 safety plans (through June 30, 2005) of Hydrogen Storage Centers of Excellence participants and provided recommendations to DOE for improvement and implementation. These safety plans, a DOE requirement for all HFCIT projects initiated in FY 2005, are prepared using the safety guidance document reviewed and updated by the Panel last year.[2] In FY 2006, the Panel expects to complete the review of all safety plans prepared for new project starts in Hydrogen Storage, Production and Delivery, and Technology Validation.

Panel members have also served the Hydrogen Safety Program in a number of other related activities over the course of FY 2005. The Panel visited the HAMMER site on November 3, 2004, for a tour/briefing and an opportunity to provide input to the

five-year plan for a National Training Facility for Hydrogen Safety. The Panel will be represented and provide feedback for HAMMER's first hydrogen-specific awareness level emergency response curriculum and course, August 30-31, 2005. Four Panel members also served as reviewers at the DOE Hydrogen Program Review Meeting held in Arlington, VA, May 23-26, 2005.

Hydrogen Education/Training

The Safety Program achieved a number of successful education and training accomplishments during the course of FY 2005.

HAMMER (HAzardous Materials Management and Emergency Response) Training Center
The HAMMER site is an existing DOE facility originally developed for training emergency responders on hazardous materials management, fire and spill safety, search and rescue, and other areas. A hydrogen safety training capability is being added to HAMMER, and a significant amount of effort devoted to different tiers of training is planned. The training structure to be used will follow the Occupational Health and Safety Administration's four-tiered approach for hazardous materials training. The different tiers correspond to the expected role and function of individuals in their emergency response organization, and include Awareness, Operations, Technician and Specialist Levels. A derivative of the Awareness level curriculum will also be developed for the purpose of preparing code enforcement officials who will be asked to approve future installations of these technologies.

Training to be offered will include not only various testing and verification activities but also a number of props that offer hands-on experience for audiences such as emergency responders or permitting officials. The initiation of these props had been planned for FY 2005 but had to be postponed due to budget limitations. However, sufficient funding was obtained to pursue development of the first tier Awareness level curriculum and to hold two pilot courses attended by a total of approximately 60 personnel. Attendees included fire service, police, Department of Transportation, and various other personnel with backgrounds related to hydrogen and/or safety.

Training activities focus on protecting the health and safety of workers, the public, and the environment by reducing risks, preventing accidents, and ensuring effective emergency response to potential accidents. HAMMER is poised to fill a critical need for the successful transition to the hydrogen economy by reassuring stakeholders and the public that the hydrogen economy of the future will be just as safe as the fossil fuel economy of today.

Feedback on the planned props continues to be pursued from a broad array of industry personnel, including the Safety Panel, fire marshals, professional trainers, and others with relevant experience to ensure the props will optimally provide the kinds of training needed.

Fuel Cell Summit Newsletter

The quarterly Fuel Cell Summit newsletter was discontinued in FY 2005 due to budget limitations.

Hydrogen and Fuel Cells Summit IX

The annual Hydrogen and Fuel Cells Summit meeting series was likewise discontinued, not only due to budget limitations, but also because it was determined to have largely served its original purpose. When the Summit series began few collaborations existed among the wide array of parties relevant to hydrogen and fuel cells codes and standards. Many committees and working groups have since formed and now independently collaborate on the needed activities, and have satisfied the original intent of the Summits.

International Activities

The U.S.' experience with hydrogen has led to interactions with other countries wishing to learn from it. In 2003, China requested assistance from the U.S., in preparation for the 2008 Summer Olympics, where they intend to build and employ a small scale hydrogen infrastructure. This fits in with larger plans of that country to eventually develop a hydrogen economy of their own.

In May, 2004, a U.S. delegation traveled to China to participate in a one-day vision development meeting as the first step in development of a Hydrogen Roadmap for China, similar to the Hydrogen Roadmap developed for the U.S. This was

followed by a "Roadmap Workshop" in January of 2005, attended by nearly 100 scientists, engineers and academicians that was designed to identify the steps needed to progress the vision developed. A U.S. delegation facilitated this second workshop. China is now in the process of developing the final roadmap document, using their notes and materials as well as those provided by the U.S. facilitators following the workshop. U.S. participation in the roadmap activity is now complete. The official Hydrogen Roadmap for China is anticipated for release at the end of 2005.

The International Energy Agency (IEA) Hydrogen Implementing Agreement officially established Task 19: Hydrogen Safety in October 2004. The first official meeting of the working group was held in March 2005 to discuss the various tasks proposed by the Operating Agent. Countries participating in the Annex which at present include the U.S., Canada, Denmark, Italy, Japan, France, the Netherlands and the United Kingdom. Three task areas are underway: A) Risk Assessment; B) Testing; and C) Development of Comprehensive Information Documents. The U.S. is participating in all tasks and manages Task C. Collaborative activities to date have primarily involved presentation of aspects of various countries' hydrogen programs and discussion of the task work scope and future products. It is anticipated that this collaborative agreement will continue through at least six years.

Conclusions

The Hydrogen Safety Program is taking an aggressive, hands-on approach in its activities. HFCIT projects are being carefully monitored and evaluated by outside experts experienced in hydrogen and safety. Emergency responders and code enforcement officials are being trained with the latest information and, soon, using hands-on techniques. Hydrogen safety-related information is being proactively shared with numerous organizations and the general public, domestically and around the world. Such an aggressive approach is mandatory to promote safe use of hydrogen and its related technologies, both now and in the future.

Moreover, the efforts undertaken to date are only the first steps to fill a much larger need if the use of various hydrogen technologies is to progress as anticipated worldwide. Widespread sharing of safety information, techniques and procedures developed in HFCIT and elsewhere will continue to be critical into the foreseeable future. Such sharing must expand beyond the capabilities of HFCIT and be embraced by the entire hydrogen community and eventually the general public itself to be successful. HFCIT can continue to encourage such progress by ensuring that new information is shared as soon as it becomes available, and is free of proprietary restriction. Safety is a public good and must be treated as such if it is in fact to achieve its desired ends.

FY 2005 Publications/Presentations

1. Kinzey, B.R., Ruiz, A., Davis, P.B., "The Hydrogen Safety Program of the U.S. Department of Energy," International Conference on Hydrogen Safety, Pisa, Italy, September 8-10, 2005.
2. Kinzey, B.R., Fassbender, L.L. and Akers, B.M., "National Training Facility for Hydrogen Safety: Five-Year Plan for HAMMER," International Conference on Hydrogen Safety, Pisa, Italy, September 8-10, 2005.
3. Weiner, S.C., Kinzey, B. and Skolnik, E.G., "Hydrogen Safety Review Panel: Shaping Safety Awareness," 20th Annual Center for Chemical Process Safety International Conference, Atlanta, GA, April 12, 2005.
4. Weiner, S.C., Kallman, R.A., Ruiz, A. and Schneider, J.M., "Hydrogen Safety: From Policies to Plans to Practices," International Conference on Hydrogen Safety, Pisa, Italy, September 8-10, 2005.

References

1. Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan, February 2005. See website: <http://www.eere.energy.gov/hydrogenandfuelcells/mypp/>
2. Guidance for Safety Aspects of Proposed Hydrogen Projects, Hydrogen, Fuel Cells and Infrastructure Technologies Program Office, Washington, DC, August 2004. See website: http://www.eere.energy.gov/hydrogenandfuelcells/pdfs/safety_guidance.pdf