VIII.2 Component Standard Research and Development

Robert Burgess (Primary Contact), William Buttner, Carl Rivkin
National Renewable Energy Laboratory (NREL)
15013 Denver West Parkway
Golden, CO 80401
Phone: (303) 275-3823
Email: robert.burgess@nrel.gov

DOE Manager
Rick Farmer
Phone: (202) 586-1623
Email: Richard.Farmer@ee.doe.gov

Project Start Date: Fiscal Year (FY) 2012
Project End Date: Project continuation and direction determined annually by DOE

Overall Objectives

- Support development of new codes and standards required for commercialization of hydrogen technologies.
- Support code development that is based on the latest scientific knowledge by providing analytical, technical, and contractual support.
- Participate directly on codes and standards committees to identify technology gaps, then work to define research and development needs required to close those gaps.
- Conduct laboratory testing to provide a basis for improved code language.
- Collaborate with industry, university and government researchers to develop improved analytical and experimental capabilities.

FY 2013 Objectives

- Collect safety/reliability data through direct communication with stakeholders and by utilizing NREL Technology Validation data to identify failure modes with highest statistical probability.
- Compile information into a report summarizing findings of failure mode investigation.
- Provide support for webinar on fueling protocols in conjunction with SAE International (SAE) interface committee, referencing SAE J2601 path forward.
- Build industry partnerships to conduct high-pressure hydrogen component and system level testing designed to understand root cause failure modes and to provide guidance for engineering best practices.
- Facilitate utilization of the new DOE Energy Systems Integration Facility (ESIF) laboratory space by identifying best use of laboratory and testing capabilities and by supporting ESIF user facility designation through interface with DOE/NREL user facility personnel.

Technical Barriers

This project addresses the following technical barriers identified in the DOE Fuel Cell Technologies Office, Safety Codes and Standards, Multi-Year Research, Development, and Demonstration (MYRD&D) Plan:

(A) Safety Data and Information: Limited Access and Availability

(C) Safety is Not Always Treated as a Continuous Process

(F) Enabling National and International Markets Requires Consistent Regulations, Codes and Standards

(G) Insufficient Technical Data to Revise Standards

(H) Insufficient Synchronization of National Codes and Standards

(J) Limited Participation of Business in the Code Development Process

(K) No Consistent Codification Plan and Process for Synchronization of R&D and Code Development

Contribution to Achievement of DOE Safety, Codes & Standards Milestones

This project contributes to achievement of the following DOE milestones from the Hydrogen Safety, Codes and Standards section of the Fuel Cell Technologies Office's Multi-Year Research, Development, and Demonstration Plan:

- Milestone 2.3: Publish protocols for identifying potential failure modes. (2Q, 2013)
- Milestone 2.11: Publish draft protocol for identifying potential failure modes and risk mitigation. (4Q, 2014)
- Milestone 2.15: Develop holistic design strategies. (4Q, 2017)
- Milestone 2.19: Validate inherently safe design for hydrogen fueling infrastructure. (4Q, 2019)
- Milestone 3.1: Develop, validate, and harmonize test measurement protocols. (4Q, 2014)
- Milestone 4.1: Complete determination of safe refueling protocols for high pressure systems. (1Q, 2012)
- Milestone 4.3: Identify and evaluate failure modes. (3Q, 2013)

FY 2013 Accomplishments

- Collected safety/reliability data through direct communication with stakeholders and by utilizing NREL Technology Validation data to identify failure modes with highest statistical probability.
- Published NREL peer reviewed report "Component Testing Report" to provide information summarizing findings of failure mode investigation.
- Participated as moderator at DOE webinar on hydrogen fueling protocols. Webinar was held in conjunction with SAE interface committee providing the technical experts who presented talks on the webinar.
- Built industry partnerships to conduct high-pressure hydrogen component and system level testing designed to understand root cause failure modes and to provide guidance for engineering best practices.
- Developed utilization plans for DOE ESIF laboratory space by identifying best use of new capabilities and by supporting ESIF user facility designation through interface with DOE/NREL user facility personnel.
- Conducted industry workshops to match industry needs with DOE/ESIF laboratory capability.

INTRODUCTION

Hydrogen safety, codes and standards has been identified in the DOE MYRD&D plan as an area where significant barriers need to be addressed. Codes and standards help ensure that hydrogen systems are safe and reliable, thereby enabling the acceptance of commercialization and growth of hydrogen technologies. NREL is providing research and development support to these codes and standards through validation testing, analytical modeling, and product commercialization efforts. NREL has been tasked with these responsibilities as defined in the DOE MYRD&D plan.

APPROACH

Hydrogen safety is being addressed by first identifying safety concerns, then developing appropriate test and analysis tasks that provide a technical basis for improved engineering methods and practices. Safety concerns are being compiled by direct discussion with key stakeholders, by leveraging existing data available through NREL's Technology Validation Sub-Program and by utilizing public outreach activities such as workshops and webinars. Identified safety concerns are prioritized, and then research and development tasks are aligned with the highest risk safety concerns. In general, the risk is defined by the combination of the severity and the likelihood of occurrence. Research and development results are then published for general use by stakeholders. Information is further disseminated through NREL outreach activities. Published results are then used as a basis for improved hydrogen codes and standards.

NREL is also participating on relevant codes and standards committees to help identify gaps and define research and development needs to close those gaps. Working at the committee level allows us to quickly identify areas that need R&D support and to work directly with the technical experts in planning a path forward. This process is instrumental in avoiding delays and setbacks in the development of new codes and standards and in the revision of existing codes and standards. By providing support from a national lab we are able to help establish codes and standards language with solid technical basis.

RESULTS

NREL has been working toward identifying safety gaps and supporting research and development efforts for developing new and improved hydrogen codes and standards. Results reported here are for efforts specifically directed at component level standards and identified hydrogen safety concerns.

Codes and Standards Technical Committee Support – NREL has supported the development of SAE J2601 (Fueling Protocols for Light Duty Gaseous Hydrogen Surface Vehicles) fueling protocols by providing technical basis for several key sections of the document. This includes the hot soak conditions from NREL's Technology Validation Composite Data Product #72 that was used as worst-case assumptions for onboard system temperatures when formulating the non-communication fill tables. SAE J2601 is planned for balloting by the end of FY 2013. NREL has also supported the release of SAE J2579 (Standard for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles), which successfully balloted as a full standard in December of 2012. NREL also supported National Fire Prevention Association (NFPA) 2 Hydrogen Technologies Code while undergoing the first major revision through participation on the technical committee and several working groups. Material for reserved applications chapters is being added. The first draft meeting was held during the first week of June 2013 at NFPA headquarters in Quincy, MA.

DOE Hydrogen Refueling Webinar (22 February, 2013) – NREL acted as moderator for this event and supported planning and logistics activities. Speakers were selected from the SAE interface committee, and included Jesse Schneider of BMW and Steve Mathison of Honda. The event was well attended and generated valuable stakeholder comments and questions. This information has been valuable input for use in developing J2601 into a full standard.

Component Testing Report (NREL report no. PR-560-48070, 31 August, 2012) – This report compiles information from stakeholders, regulations codes and standards technical committees and outreach activities to itemize needs and gaps for safety and reliability of hydrogen systems. Leveraging of NREL Technology Validation data was also used to identify safety and reliability issues that have shown through field evaluation to be statistically higher occurrence and therefore of greater safety concern.

ESIF Laboratory Planning – NREL took occupancy of a new DOE laboratory building, ESIF, in December of 2012. This laboratory building provides the Hydrogen Safety, Codes and Standards Sub-Program with a valuable resource for conducting research and development activities. As part of this effort, a process hazard analysis was conducted and a five-year plan was produced.

Research and Development Outreach Activities – Numerous outreach activities were conducted in conjunction with the DOE/NREL Hydrogen Safety, Codes and Standards Sub-Program. These activities are used as a resource in soliciting feedback from industry and identifying priorities for research and development tasks. Significant outreach activities include: 1) conducting SAE J2601/NFPA 2 joint call to coordinate references and interrelated content in these documents; 2) participation on DOE-organized relief valve field failure task torce, which led to NREL removing similar relief valves from hydrogen service and reserving them for future root cause validation testing; 3) work for Others activity through the California Department of Food and Agriculture weights and measures project which has been instrumental in identifying gaps and needs for hydrogen metering; 4) participation on NREL Pressure Safety Panel to identify DOE laboratory protocols for the safe use of high-pressure hydrogen at a DOE laboratory; and 5) participation on Non-Metallic Materials workshop led by Sandia, addressing issues with elastomers used in high-pressure hydrogen service and the need to produce safe, leak tight systems.

CONCLUSIONS AND FUTURE DIRECTION

NREL has identified numerous opportunities to further improve the inherent safety of high-pressure hydrogen systems that are designed to serve fuel cell electric vehicle markets. These opportunities must be pursued through a variety of means, including failure mode testing investigations, root cause analysis and codes and standards development. Proposed future direction will utilize existing data generated by the Technology Validation Sub-Program and include research and development tasks that are aimed at improving the safety and reliability of high-pressure hydrogen systems. The new ESIF laboratory includes capability for component and system level testing that can be leveraged in support of fuel cell electric vehicle deployment activities.

FY 2013 PUBLICATIONS

1. "Component Standard Research and Development", DOE Annual Merit Review, May 14th, 2013.

2. "NREL Hydrogen Safety Plan, Annex II Hydrogen Component Testing", March 2013.

3. "DOE Workshop Series" sponsored by Secretary Chu, Poster Presentation "NREL Sensor Testing", Chicago IL, September 24–25, 2012.

4. "Component Testing Report, Hydrogen Safety Codes and Standards, FY12 AOP Deliverable 7.5", August 31st, 2012.