VIII.3 Component Standard Research and Development

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Project Start Date: FY 2008
Project End Date: Project continuation and direction determined annually by DOE.

Fiscal Year (FY) 2011 Objectives

- Support development of new codes and standards required for commercialization of hydrogen technologies.
- Create code language 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.

Technical Barriers

This project addresses the following technical barriers from the Hydrogen Codes and Standards section (3.7.4) of the Fuel Cell Technologies Program's Multi-Year Research, Development and Demonstration Plan:

(A) Limited Government Influence on Model Codes
(B) Competition among SDOs and CDOs
(C) Limited State Funds for New Codes
(F) Limited DOE Role in the Development of International Standards
(G) Inadequate Representation at International Forums
(H) International Competitiveness
(I) Conflicts between Domestic and International Standards
(J) Lack of National Consensus on Codes and Standards
(K) Lack of Sustained Domestic Industry Support at International Technical Committees
(N) Insufficient Technical Data to Revise Standards

Contribution to Achievement of DOE Safety, Codes & Standards Milestones

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

- **Milestone 21**: Completion of necessary codes and standards needed for the early commercialization and market entry of hydrogen energy technologies. (4Q, 2012)

FY 2011 Accomplishments

- Completed sensor test laboratory objective, round I and II of the NREL/Joint Research Centre (JRC) round robin inter-laboratory comparison, completed under a formal Memorandum of Understanding with the JRC laboratory (a European Commission funded laboratory). Round robin test result comparison provided validation of test methods.
- Hydrogen safety sensor market characterization composite data study is approximately 50% complete.
- Collaborative partnerships were established to develop four new hydrogen safety sensor technologies. These technologies are being developed by both public and private organizations. Testing of each of these sensor technologies was completed as part of NREL's sensor evaluation process.
- NREL/DOE field deployment study was completed in support of hydrogen safety sensor installation in an NREL facility. This study included testing sensors being evaluated by NREL's Environmental Health and Safety organization. NREL hosted a hydrogen safety sensor workshop, June 2011 to bring together key industry representatives. Results included defining gaps and setting research and development needs for sensor commercialization.
- Conducted hydrogen pressure relief device (HPRD) contract testing in support of HPRD1 component standards development. Test results were used to modify test protocols defined in the draft standard.

Introduction

Development of codes and standards has been identified in the DOE multi-year program plan as a key area needing support for the commercialization and growth of hydrogen technologies. NREL is providing research and development (R&D) support to these codes and standards organizations through validation testing, analytical modeling, and product commercialization efforts. NREL has been tasked with these responsibilities as defined in the DOE multi-year program plan.

Approach

NREL is participating on relevant codes and standards committees to help identify gaps and define R&D 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.

Hydrogen safety sensors are a key component for the safe commercialization of hydrogen technologies. NREL is tasked with being a national resource for testing sensors designed to meet the needs of this growing market. By developing standard test methods and measuring sensor performance of a wide range of sensors of different designs and from a many different manufacturers, NREL is characterizing sensor performance and identifying gaps relative to DOE performance targets. With this information we work closely with sensor manufacturers so that they can better understand the performance of their sensor relative to the needs of hydrogen stationary applications. This work is directed toward sensor R&D, such that sensor manufacturers, utilizing the resources of a national lab, can expedite their product development life cycle. In addition, the sensor market expertise gained by NREL will be used to support commercialization through development of representative codes and standards for safety sensor certification. Commercialization support includes collaboration with key stakeholders as well as direct participation on the relevant codes and standards committees.

Results

NREL has been working toward identifying gaps and supporting R&D efforts for developing new and improved hydrogen codes and standards. Results reported here are for efforts specifically directed at component level standards. Results are organized in the following three sections; Hydrogen Safety Sensors, Canadian Standards Association (CSA) HPRD1 and Codes and Standards Support.

Hydrogen Safety Sensors

DOE published performance targets for hydrogen safety sensors in the multi-year program plan. NREL has tested more than 40 commercially available sensors and near-term developmental sensors from six sensor categories. This test data is being compiled in a generic format as a resource for end users. This format will allow for publishing a characterization study of the sensor market, while keeping individual results proprietary. NREL is approximately 50% complete with compilation of this composite data product.

NREL completed validation testing of the sensor test apparatus that was built in FY 2010. Validation testing consisted of systems level testing to characterize the repeatability and reproducibility of the apparatus, showing capabilities surpassing requirements in certification standards. Capabilities were further validated through round robin testing completed with the JRC Institute for Energy laboratory in Petten, Netherlands.

NREL is currently working directly with more than 20 sensor developers to support commercialization as their products move from prototype designs to full-scale production. This effort is directed at providing independent evaluation and testing of sensor platforms. This work has been completed in conjunction with other DOE supported projects in developing new technologies that have shown promise in meeting the identified DOE sensor targets.

CSA HPRD1

Pressure relief devices have been identified as a key safety component on hydrogen storage systems. Inadvertent opening can result in a failure mode where there is a release of the entire contents of the storage vessel. CSA component standard HPRD1 is in draft format. This standard defines performance-based certification tests designed to show end-of-life reliability. NREL and CSA worked together to define validation testing required for hydrogen service suitability testing as part of the CSA HPRD1 draft standard. Defined testing includes pneumatic cycle testing in hydrogen on three valves of three different designs, three surrogate designs and post-test metallurgical examination. Test results identified leakage issues at -40°C low temperature test conditions. Further evaluation of the test methods identified thermal transients that were more severe than the valves would see in actual low temperature service. This information was reviewed by the HPRD1 technical committee, concluding that a revised set of test conditions are required to more accurately depict worst case low temperature operation. Revised test definitions now include low temperature soak conditions. Testing was repeated successfully validating the revised test procedures. HPRD validation testing has been completed based on a revised test scope to both validate the revised test protocol and to stay within the budgetary limits first determined within this subcontract test program. A final report is being written for completion within FY 2011.

Codes and Standards Support

Through direct participation on the hydrogen components codes and standards committees, NREL has identified R&D gaps, including further HPRD testing, localized fire testing, tank level stress rupture testing and radio-frequency identification fill protocol validation. NREL has developed statements of work required to close these gaps and finalize these components requirements.

Conclusions and Future Direction

NREL made significant contributions in supporting commercialization of hydrogen sensor technologies. This includes collaborative work with domestic and international partners. NREL hosted a hydrogen sensor workshop in June 2011to identify R&D gaps to help define future sensor test laboratory direction. We completed validation testing in support of HPRD1 component standards and continue to work closely with codes and standards development organizations to close gaps and promulgate codes and standards that are based on the latest technical knowledge.

In addition to continuing to support component level codes and standards development, NREL will undertake a number of initiatives including:

- Identifying gaps to hydrogen technology commercialization.
- Providing national laboratory support needed to provide a sound basis for component level codes and standards content.
- Working directly with sensor manufacturers in order to reach performance targets defined in the DOE multi-year program plan.
- Executing sensor laboratory testing over a wider range of environmental conditions and finalizing long-term exposure and response time testing methodologies.
- Leveraging our efforts with national and international collaborations to provide a path toward commercialization of hydrogen components that are designed to meet the latest safety standards.

FY 2011 Publications/Presentations

1. "An Overview of Hydrogen Safety Sensors and Requirements," Buttner et al., 3rd International Conference on Hydrogen Safety (ICHS), September 2009 (publication in International Journal of Hydrogen Energy, 2010 special issue).

2. "Indoor Hydrogen Fueling Safety Codes and Standards," Rivkin, C. and Buttner, W.J., Proceedings of the National Hydrogen Association Conference and Expo, Long Beach, CA, May 3–6, 2010.

3. "Round Robin Testing of Commercial Hydrogen Sensor Performance – Observations and Results," Buttner, W.; Burgess, R.; Rivkin, C.; Post, M.; Boon-Brett, L.; Black, G.; Harskamp, F.;. Moretto, P.; Proceedings of the National Hydrogen Association Conference and Expo, Long Beach, CA, May 3–6, 2010.

4. "Round Robin Testing of Commercial Hydrogen Sensor Performance – Observations and Results,".Post, M., NHA Conference and Expo, May 2010.

5. "Hydrogen Sensor Performance – Calibration and Maintenance Issues," Buttner, W.; Post, M.; Burgess, R.; Rivkin, C.; Telcordia Fire Forum Denver, CO September 2, 2010.

6. "U.S. DOE Hydrogen Component and System Qualification Workshop Summary," Sandia National Laboratory, Livermore , CA, November 4, 2010.

7. "SAE J2579 Validation Testing Program Powertech: Final Report," McDougall, M., NREL Report No. SR-5600-49867, Dec 2010.

8. "Hydrogen Safety Sensor Testing and Deployment--The NREL Sensor Laboratory," Buttner, W. J.; Burgess, R.; Post, M.; Rivkin, C.; to be published in the Proceedings of the Fuel Cell and Hydrogen Energy Association Conference, February 13–16, 2011, National Harbor, MD.

9. "Validation Testing in Support of Hydrogen Codes and Standards Development," Burgess, R.; McDougall, M.; Newhouse, N.; Buttner, W.; Rivkin, C.; Post, M.; International Conference on Hydrogen Safety (ICHS), Sep 2011.

10. "Matrix Effects on Hydrogen Safety Sensors," Buttner, W.J.; Burgess, R.; Rivkin, C.;. Post, M.; Boon-Brett, L.; Black, G.; Harskamp, F.; Moretto, P.; International Conference on Hydrogen Safety (ICHS), San Francisco, September, 2011.