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## VIII.2 Component Standard Research and Development

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Project Start Date: October 1, 2012

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

### Overall Objectives

- Accelerate development of codes and standards required for commercialization of hydrogen technologies.
- Codify standards language that is based on the latest scientific knowledge by providing analytical, technical and contractual support.
- Contribute directly to codes and standards committee efforts to identify technology gaps, then work to define research and development needs required to close those gaps.
- Build laboratory testing capability and conduct research and development aimed at providing the basis for improved code language.
- Collaborate with industry, university and government researchers to develop improved analytical and experimental capabilities.

### Fiscal Year (FY) 2014 Objectives

- Coordinate infrastructure research and development support through interface with H2USA and H2FIRST organizations.
- Generate report on pressure relief valve technologies to provide industry with latest information on proper hydrogen design and system application.
- Conduct webinar on component testing activities and lessons learned, primary target audience is component designers and system suppliers.
- 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.

- Work in partnership with National Institute of Standards and Technology Fluid Metrology Group and state agencies to advance knowledge of hydrogen metrology methods for hydrogen dispensing weights and measures.
- 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 Safety Codes and Standards section of the Fuel Cell Technologies Office 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 RCS
- (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 Hydrogen Safety, Codes and 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 MYRD&D 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 2014 Accomplishments

- Published NREL peer review report “Pressure Relief Devices for High-Pressure Gaseous Storage Systems: Applicability to Hydrogen Technology” to provide information on best practices for hydrogen component design and selection.
- Prepared presentation materials for hydrogen component webinar. Webinar plans are being finalized, dates in the fourth quarter of FY 2014 are being considered. The webinar addresses hydrogen component design, performance and operational topics.
- Represented DOE and NREL at interagency meetings with National Institute of Standards and Technology on the subject of hydrogen metrology with the purpose of supporting state weights and measures inspectors as they are preparing to issue use permits for the sale of hydrogen at public dispensers.
- Designed and built apparatus for high-pressure hydrogen component and system level testing designed to understand root cause failure modes and to provide guidance for best practices. Test planning for FY 2015.
- Hosted the National Fire Protection Association (NFPA) joint document review meetings for NFPA 2 Hydrogen Technologies Committee and NFPA 55 Industrial and Medical Gas Committee.
- Coordination of component activities with H2USA and H2FIRST, facilitating national laboratory support of hydrogen infrastructure projects.



## INTRODUCTION

Hydrogen safety, codes and standards topics have been identified in the DOE MYRD&D Plan as a subject area where significant barriers need to be addressed. Developing robust codes and standards helps to ensure that hydrogen systems are safe and reliable, thereby enabling the acceptance 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 best practices. Safety concerns are being compiled by direct discussion with key stakeholders, by leveraging existing data available through NREL’s Technology Validation 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 (R&D) results are then published for general use by stakeholders. Information is further disseminated through NREL outreach activities. Published results are also being used as a basis for improved hydrogen codes and standards.

NREL is 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. R&D support is being used to establish codes and standards language with solid technical basis.

## RESULTS

NREL has been working toward identifying safety 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 and identified hydrogen safety concerns.

**Codes and Standards Technical Committee Support** – NREL provided development support for the SAE International (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 data that was used as worst case assumptions for onboard system temperatures when formulating the non-communication fill tables. SAE J2601 has successfully passed balloting and is now available through SAE publications as of July 2014. NREL also supported NFPA 2 Hydrogen Technologies Code by hosting the joint meeting with NFPA 55 in July 2014. These two standards are on a synchronized revision schedule to simplify hydrogen content improvements.

**NREL Hydrogen Component Webinar (Fourth Quarter FY 2014)** – NREL has completed presentation materials for a component webinar. Presentation material

is currently being reviewed by DOE for a fourth quarter presentation date. The webinar provides valuable input for component suppliers and system developers.

**Pressure Relief Valve Report (NREL report no. TP-5400-60175, November, 2013)** – This NREL report, peer reviewed by industry, compiles information on the proper design, installation and operation of pressure safety devices in hydrogen service. Addressing safety concern by providing relevant best practices information will help to prevent future failures during field operation.

**Pressure Relief Valve Failure Mode Demonstration** – NREL is conducting a qualitative reliability test failure mode investigation by using the high-pressure testing capability at NREL. This test is designed to replicate a known field failure mode under laboratory controlled conditions and to provide insight into the necessary and sufficient conditions required to produce a component level failure. Testing hardware has been designed and assembled and is currently undergoing system check out testing with a planned test start date by the end of FY 2014 with continued testing into FY 2015.

**Component Crosscutting Accomplishments** – NREL is conducting DOE-funded component tasks under other subprograms including hose/dispenser and compressor testing. In FY 2014 NREL also completed a work for others task for the California Department of Food and Agriculture to construct a device for evaluating hydrogen metrology methods. These efforts have provided an opportunity to leverage safety codes and standards objectives through crosscutting activities. These activities include regulations, codes, and standards guidance for defining test protocols and design requirements. The safety codes and standards program is also benefiting from component test results that are the technical basis for improved code requirements.

**Research and Development Outreach Activities** – Numerous outreach activities were conducted in conjunction with the DOE/NREL safety, codes and standards activities. Outreach activities are used as a resource in soliciting industry feedback and identifying priorities for research and development tasks. Outreach tasks include contribution to key technical committees and working groups at H2USA, H2FIRST, California Fuel Cell Partnership and work with other key stakeholders.

## 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. Future direction will include R&D activities that utilize existing ESIF laboratory facilities for component and system level testing.

## FY 2014 PUBLICATIONS/PRESENTATIONS

1. “Component Standard Research and Development”, DOE Annual Merit Review, June 18<sup>th</sup>, 2014.
2. “Pressure Relief Devices for High-Pressure Gaseous Storage Systems: Applicability to Hydrogen Technology”, NREL Technical Report TP-5400-60175, A. Kostival, C. Rivkin, W. Buttner, R. Burgess, Nov 2013.