VIII.1 Hydrogen Safety Codes and Standards

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- University of South Carolina Research Foundation, Columbia, SC
- Hawaii Natural Energy Institute at the University of Hawaii, Honolulu, HI
- Jet Propulsion Laboratory, Pasadena, CA
- National Association of State Fire Marshals, Washington, D.C.
- Smart Chemistry, Sacramento, CA

Project Start Date: 1995
Project End Date: Project continuation and direction determined annually by DOE

Objectives

- Conduct research and development (R&D) needed to establish sound technical requirements for hydrogen codes and standards.
- Support code development for the safe use of hydrogen in commercial, residential, and transportation applications.
- Advance hydrogen safety, code development, and market transformation issues through collaborations with appropriate stakeholders.
- Facilitate the safe deployment of hydrogen technologies.

Technical Barriers

This project addresses the following technical barriers from section 3.7.4 of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

Limited Government Influence on Model Codes

(A) Competition among Standards-Development Organizations (SDOs) and Code-Development Organizations (CDOs)

(B) Limited State Funds for New Codes

(C) Large Number of Local Government Jurisdictions (approximately 44,000)

(D) Lack of Consistency in Training of Officials

(E) Limited DOE Role in the Development of International Standards

(F) Inadequate Representation at International Forums

(G) International Competitiveness

(H) Conflicts between Domestic and International Standards

(I) Lack of National Consensus on Codes and Standards

(J) Lack of Sustained Domestic Industry Support at International Technical Committees

(K) Competition in Sales of Published Standards

(L) Jurisdictional Legacy Issues

(M) Insufficient Technical Data to Revise Standards

(N) Affordable Insurance is Not Available

(O) Large Footprint Requirements for Hydrogen Refueling Stations

(P) Parking and other Access Restrictions

Contribution to Achievement of DOE Safety, Codes & Standards Milestones

This project will contribute to achievement of the following Hydrogen Codes and Standards milestone from the DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program 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)

Accomplishments

NREL has accomplished the following in support of section 3.7 of the DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- *Hydrogen sensor testing and validation*: Began collaborations with key stakeholders; worked on a formal agreement with the European Commission's Joint Research Centre (JRC) laboratory for testing hydrogen safety sensors; started testing commercially available sensors; participated on

International Standards Organization (ISO) TC197 WG13 to develop a hydrogen sensor standard.

- *Component testing*: Conducted validation testing of high-pressure onboard hydrogen storage systems; tested hydrogen fueling station breakaways, fittings, nozzles, and hoses; began work on hydrogen pressure release device (HPRD) testing. This work would be used to develop a HPRD standard by CSA America.
- *Fuel quality specification*: Worked with ISO on technical specification 14687-2; conducted validation testing of particulate measurement methodology; coordinated testing and modeling to understand the effects of contaminants on fuel cell performance.
- *Modeling/simulation of leak scenarios in residential garages*: Presented modeling results at the 2nd International Conference for Hydrogen Safety; began validation testing at NREL's Thermal Test Facility on full-scale garage model; worked with computational fluid dynamics (CFD) group to develop a modeling/test validation protocol.
- *Codes and standards development*: Worked with CDOs and SDOs to develop codes, identify gaps, and provide R&D support; participated on National Hydrogen and Fuel Cell Codes and Standards Coordinating Committee, DOE Codes and Standards Technical Team, and Hydrogen Industry Panel on Codes (HIPOC); assisted DOE Golden Field Office in moving responsibilities for subcontract support to CDOs and SDOs.
- *Permitting workshops*: Launched a DOE initiative to facilitate the permitting of hydrogen fueling stations and hydrogen powered fuel cells for telecommunications and other applications: developed a virtual permitting workshop activity using actual design details for a hydrogen fueling station.
- *Web-based information compendium*: Released Web-based information compendium as a reference for permitting workshop participants and the public; began expanding compendium to include other fuel cell applications.

Introduction

It is essential to develop and promulgate codes and standards in order to provide for the safe use of hydrogen technologies and establish a market-receptive environment for hydrogen-based products and systems so that hydrogen can become a significant energy carrier and fuel. With the help of key stakeholders, the DOE Hydrogen, Fuel Cells, and Infrastructure Technologies Program and NREL are coordinating a collaborative national effort to prepare, review, and promulgate hydrogen codes and standards needed to expedite the development of a hydrogen infrastructure.

DOE has also launched a comprehensive research, development, and demonstration (RD&D) effort to obtain the data needed to establish a scientific basis for the requirements incorporated in hydrogen codes and standards. This RD&D is planned, conducted, and evaluated in collaboration with industry through the U.S. FreedomCAR and Fuel Partnership (FCFP) to examine and advance pre-competitive R&D of technologies, enable high-volume production of affordable hydrogen fuel cell vehicles, and establish a supporting national hydrogen infrastructure.

Approach

The federal government has an indirect role in the voluntary consensus process through which codes and standards are developed in the United States (Barrier A). It is important to establish a harmonized set of model codes and regulations and standards which these codes and regulations reference. Therefore, DOE, primarily through NREL, has devoted considerable effort to facilitating and coordinating this consensus process.

NREL assists DOE and the FCFP Codes and Standards Technical Team in implementing the RD&D Roadmap by coordinating and conducting the activities needed to establish sound technical requirements for standards, codes, and regulations for hydrogen components and systems. Key RD&D areas supported by NREL include integrated engineering approaches to hydrogen safety and hydrogen component testing to develop data for requirements incorporated in component standards.

Results

DOE has identified the 2012 targets for hydrogen safety sensor performance. NREL is testing both commercially available and near-term developmental sensors to identify performance variables relative to the DOE targets. Through work with key stakeholders, NREL is identifying the gaps in technologies and determining R&D needs. As part of this effort, NREL is working on a formal collaboration agreement with the Institute of Energy in Petten, Netherlands, a JRC laboratory.

NREL is also conducting component testing that can be used to validate code requirements and provide a sound technical basis for new performance-based standards. Test requirements are defined by the relevant CDOs and SDOs and translated into statements of work. Component testing supports both SAE and Canadian Standards Association standards development.

Fuel quality work at NREL falls in two categories: identifying contaminants in the fuel stream, and testing the effects of critical contaminants on fuel cell performance. NREL has completed work on a fuel sample test apparatus that can be used at the hydrogen fueling station to obtain gas samples. We are also conducting microscopy tests of particulate matter and working with others to conduct round-robin fuel cell performance tests to determine the effect of gaseous contaminants on fuel cell performance.

In addition, NREL has published results of a CFD study on leak scenarios in residential garages. Full-scale experimental validation of the CFD model is being done in NREL's Thermal Test Facility.

To help manage the hydrogen safety codes and standards development process, NREL is working at the coordinating committee level. Committees include the National Hydrogen and Fuel Cell Codes and Standards Coordinating Committee, DOE's Codes and Standards Technical Team, and HIPOC. NREL is also contributing to both national and international standards committees, such as National Fire Protection Association 2, the SAE Fuel Cell Safety Group, and ISO TC 197. With DOE's Golden Field Office, NREL provides support and monitors the progress of work by CDOs and SDOs that is coordinated by Regulatory Logic, LLC.

Facilitating the permitting of hydrogen fueling stations is a high priority for the FCFP and the Secretary of Energy's Hydrogen Technical Advisory Panel. NREL is continuing work on a DOE initiative to address this need by organizing workshops that include fueling station developers, state and local code officials, and other interested parties. These well-received workshops are targeting regions in which early adoption is planned. Further work includes the following:

- Developing a Web-based information repository for permitting officials that streamlines the permitting process; the repository, which is available now, is being expanded to include information on other applications, such as stationary power installations.
- Providing code officials at workshops with a template to better understand the permitting process specific to their regions.
- Compiling a hydrogen technologies fact sheet that includes details about equipment needs for permitting officials.

Conclusions and Future Directions

NREL will continue to support the development of hydrogen codes and standards by–

- Working with DOE and Regulatory Logic to implement a national template for hydrogen codes and standards development.
- Continuing R&D support of the key technologies required to close the gaps identified in the codes and standards development process.
- Continuing R&D collaborations with national and international stakeholders on hydrogen safety codes and standards activities.
- Building on coordinating committee efforts to further consolidate and coordinate domestic and international codes and standards activities.

FY 2008 Publications/Presentations

1. D. Barley et al., "Analysis of Buoyancy-Driven Ventilation of Hydrogen from Buildings," ICHS-2, 2007.

2. C. Blake, "A National Agenda for Hydrogen Codes and Standards," International Symposium on the Hydrogen Economy, 2007.

3. C. Blake and J. Ohi, "A National Agenda for Hydrogen Codes and Standards," International Symposium on the Hydrogen Economy, 2007.

4. Hydrogen Fuel Quality R&D/Testing, Workshop on Fuel Quality Modeling, Argonne, IL, August 30, 2007.

5. "NFPA's Hydrogen Technologies Code Project," published in the proceedings of the AIChE 2008 Loss Prevention Symposium.

6. "NFPA 2 – NFPA's Comprehensive Hydrogen Technologies Code," published in the proceedings of the 2008 National Hydrogen Association Annual meeting.

7. J. Ohi, "Hydrogen Codes and Standards," chapter in *Hydrogen Energy*, CRC Press, in press.

8. J. Ohi, "Permitting Hydrogen Fueling Stations: DOE Initiative," keynote for the Next Energy Annual Conference, 2007.

9. J. Ohi, "Hydrogen Safety and Permitting Hydrogen Fueling Stations," ICHS-2, 2007.

10. J. Ohi (co-author), "Risk-Informed Process and Tools for Permitting Hydrogen Fueling Stations," ICHS-2, 2007.