

VII.1 Hydrogen Codes and Standards

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Subcontractors:

- Battelle Memorial Institute, Columbus, OH
- Society of Automotive Engineers, Warrendale, PA

Start Date: 1995

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

- (E) Lack of Consistency in Training of Officials
- (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
- (L) Competition in Sales of Published Standards
- (M) Jurisdictional Legacy Issues
- (N) Insufficient Technical Data to Revise Standards
- (O) Affordable Insurance is Not Available
- (P) Large Footprint Requirements for Hydrogen Refueling Stations
- (Q) Parking and Other Access Restrictions

Objectives

- Coordinate and conduct research and development (R&D) needed to establish sound technical requirements for standards, codes, and regulations for hydrogen components and systems.
- Facilitate development and adoption of model building codes and equipment standards for hydrogen systems in commercial, residential, and transportation applications.
- Facilitate permitting of hydrogen fueling stations.
- Provide technical resources to harmonize development of international standards among the International Organization for Standardization (ISO), International Electrotechnical Commission (IEC), and Working Party on Pollution and Energy (GRPE).

Technical Barriers

This project addresses the following key technical barriers from the Hydrogen Codes and Standards section (3.6) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program 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
- (D) Large Number of Local Government Jurisdictions (approximately 44,000)

Contribution to Achievement of DOE Codes and Standards Milestones

This project will contribute to achievement of the following DOE Hydrogen Codes and Standards milestones from the Codes and Standards section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

- **Milestone 17** – Templates of commercially viable footprints for fueling stations that incorporate advanced technologies developed. (3Q 2007)
- **Milestone 18** – Implement research program to support new technical committees for the key standards including fueling interface, and fuel storage. (4Q 2007)
- **Milestone 19** – Final draft standards completed for transportable composite containers for balloting (American Society of Mechanical Engineers). (1Q 2008)
- **Milestone 20** – Draft standards for hydrogen detectors in stationary applications (Underwriters Laboratories). (4Q 2008)
- **Milestone 21** – Completion of necessary codes and standards needed for the early commercialization and market entry of hydrogen energy technologies. (4Q 2012)

Accomplishments

Implemented Codes and Standards Tech Team RD&D Roadmap by conducting and coordinating RD&D to establish defensible requirements for standards.

- Computational fluid dynamics (CFD) modeling of hydrogen leaks in residential garages:
 - Paper accepted for presentation at the 2nd International Conference for Hydrogen Safety (ICHS-2).
 - Established informal CFD modeling group (Sandia National Laboratories, National Institute for Standards and Technology [NIST], National Research Council Canada, NREL) to coordinate work and share data.
- Hydrogen sensor testing and validation:
 - Prepared initial design of laboratory layout and equipment needs.
- Component testing:
 - Initiated validation of testing parameters and sequence for on-board tanks (SAE 2579).
 - Initiated testing for 70 MPa dispenser systems and components (SAE 2799, et al).
 - Conducted computer-assisted engineering (CAE) modeling to simulate NGV-2 test criteria and testing of carbon composite tanks under a collaborative project with industry.

Unified national agenda for codes and standards:

- Launched DOE initiative to facilitate the permitting of hydrogen fueling stations (HFSs).
 - Conducted workshops in Sacramento and Atlanta with HFS developers and code officials.
 - Initiated development of web-based HFS information repository to provide third party information and data on hydrogen technologies, HFS permitting processes, and relevant codes and standards.
- Conducted monthly teleconference meetings of the National Hydrogen and Fuel Cell Codes and Standards Coordinating Committee (NHFC4).
- Worked with and assisted DOE/GO to facilitate the transition of responsibilities for subcontract support to standard development organizations (SDO) and model code development organizations (CDO) from NREL to the prime contractor, Regulatory Logic, LLC.
- Hosted first meeting of National Fire Protection Association (NFPA) 2 (Hydrogen Technologies), which will bring all of the hydrogen-related requirements in seven NFPA documents into a single harmonized document:

- Member of NFPA 2 task groups on separation distances and fueling station requirements.

International coordination of projects under ISO, International Energy Agency (IEA), European Community (EC), and other organizations for DOE.

- Chaired ISO Ad hoc Working Group to develop inventory and status report on ISO and IEC standards for hydrogen components.
- Represented DOE on HyApproval, an EC project to harmonize hydrogen fueling station requirements in the EC, Japan, China, and the U.S.
- Represented DOE on Organizing Committee meeting for ICHS-2.
- Participated in meeting of U.S. Fuel Cell Council and Fuel Cell Commercialization Conference of Japan (FCCJ) on fuel cell test protocols.
- Worked with DOE and Hydrogen Industry Panel on Codes (HIPOC) to coordinate interaction with Bureau de normalisation du Quebec to harmonize hydrogen fueling station siting requirements in NFPA and International Code Council (ICC) codes with the newly developed Canadian Hydrogen Installation Code.



Introduction

The development and promulgation of codes and standards are essential for establishing a market-receptive environment for hydrogen-based products and systems and, in turn, for hydrogen to become a significant energy carrier and fuel. With the help of key stakeholders, the DOE Hydrogen, Fuel Cells, and Infrastructure Technologies (HFCIT) Program and NREL are coordinating a collaborative national effort to prepare, review, and promulgate hydrogen codes and standards needed to expedite hydrogen infrastructure development.

The DOE Hydrogen Codes and Standards Program has also launched a comprehensive research, development, and demonstration (RD&D) effort to obtain the data needed to establish a scientific basis for 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) formed to examine and advance pre-competitive research and development of technologies to enable high volume production of affordable hydrogen fuel cell vehicles and the national hydrogen infrastructure necessary to support them. The codes and standards activities of the FCFP are conducted through the Codes and Standards Technical Team that adopted a Roadmap to guide the RD&D.

Approach

The federal government has an indirect and relatively limited role in the voluntary consensus process through which codes and standards are developed in the United States (Barrier A). Because of the importance of establishing a harmonized set of standards on which model codes and regulations can be based, DOE, primarily through NREL, has devoted considerable effort to facilitating and coordinating this consensus process.

NREL helps DOE and the FCFP Codes and Standards Technical Team implement the RD&D Roadmap by coordinating and conducting RD&D 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

Facilitating the permitting of HFSs is a high priority for both the FCFP and the Secretary of Energy’s Hydrogen Technical Advisory Panel. NREL launched a DOE initiative to address this need by organizing and conducting a kick-off workshop in Sacramento, CA, that brought together HFS developers, state and local code officials, and other interested parties. The key output from the workshop was a set of findings and recommendations to DOE on how it could help to facilitate the permitting of HFSs:

- Develop an information repository for HFSs with validated third party data and information.
 - Identify applicable codes and standards (specific safety requirements) and make them more accessible to permitting officials.
 - Develop a detailed process flowchart for permitting HFSs.
- Develop a template for code officials to navigate the permitting process.
- Note best practices for application of codes and standards for HFSs.
 - Develop fact sheets on hydrogen technologies and HFS equipment for permitting officials.
 - Develop a permitting pathway from “behind the fence” stations to retail stations.

NREL is developing a web-based information repository as recommended. A concept for an HFS information repository is shown in Figure 1, with potential outputs noted in brackets. Items included under “Permitting Process” and “Retail Hydrogen Station” will be linked to specific sections of applicable codes and standards as appropriate.

NREL and DOE conducted a second workshop with the National Association of State Fire Marshals (NASFM) in Atlanta, GA, with key fire and building code officials to review and apply available codes and standards to five “case studies” of HFS site plans prepared by two leading energy companies. These case studies covered the likely near-term configurations of HFSs. The key outcomes of this workshop were the identification of needed modifications in the primary

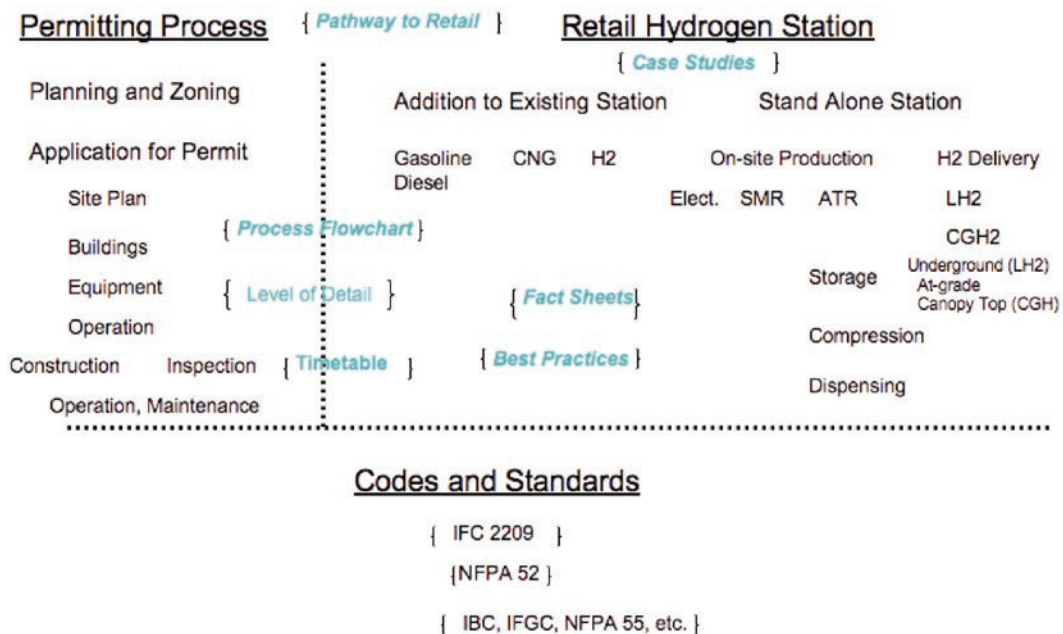


FIGURE 1. Concept for Information Repository for Permitting Hydrogen Fueling Stations

codes and standards used for permitting HFSs, the delineation of the level of detail of critical information needed in the permitting process, and the linkage of the permitting process to land-use planning and zoning issues. NREL will continue to support DOE in this initiative by conducting additional national and regional workshops and by launching the information repository by the end of the calendar year.

NREL also works with HIPOC that provides a neutral forum to develop and submit hydrogen-related code provisions to both the ICC and the NFPA. The HIPOC plays a key role in harmonizing provisions in ICC and NFPA codes and standards. In FY 2007, NREL worked with HIPOC on evaluating new proposals for the ICC family of model codes.

NREL is a member of the Technical Committee for NFPA 2 (Hydrogen Technologies) as well as task groups on separation distances and fueling station requirements. NFPA 2 will bring all of the hydrogen-related requirements in seven NFPA documents into a single harmonized document by 2010. NFPA 2 has the potential to become a national hydrogen code, analogous to the National Electric Code (NFPA 70).

NREL also coordinated DOE support to the NFPA Research Foundation to address priority R&D needs related to the hydrogen codes and standards identified by industry. For example, DOE co-funded a study with industry to develop data to support new requirements for hydrogen stored in cylinders housed in passively vented, noncombustible enclosures. Hydrogen releases from such cylinders were modeled with a CFD code. This work was conducted in conjunction with the code revision cycle for NFPA 55 (Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks) and guided by a technical committee of representatives from industry, government, and academia. The study examined only the consequences of hydrogen releases (flammable vapor cloud formation, radiative flux from ignited plumes, overpressures from detonations) that suggested larger separation distances than are currently stipulated in NFPA 55. The next step will be for members of the NFPA 55 Technical Committee to consider the suggested separation distances in the context of risk management and potential mitigation measures.

In international codes and standards, NREL represents DOE in HyApproval, an EC project to harmonize requirements for HFSs in Europe. The U.S., Japan, and China are non-EC partners in this project. The main product of HyApproval will be a handbook on requirements and procedures to permit HFSs in the EC. NREL is also active in the U.S. Technical Advisory Group for the ISO as well as several working groups of ISO Technical Committee 197 (Hydrogen Technologies)

that are developing international standards for hydrogen energy applications.

The RD&D Roadmap of the Codes and Standards Technical Team helps guide DOE activities that will provide data required for SDOs to develop performance-based codes and standards for a commercial hydrogen energy sector in the U.S. NREL supports the DOE and the team in the Fuel-Vehicle Interface focus area of the Roadmap. One task under this focus area is integrated engineering approaches to hydrogen safety for which NREL developed a fiber-optic hydrogen sensor that is now licensed to a private company. Another task is CFD modeling of hydrogen leaks from vehicles in an attached garage of an energy-efficient single-family house built under DOE's Building America Program. The CFD modeling will help NREL develop guidelines to design and build homes with architectural safety features that maximize safety with minimal compromise of building energy efficiency. NREL is also a member of an informal CFD modeling group with other experts from Sandia National Laboratories, NIST, and National Research Council Canada to encourage collaboration and sharing data and information.

Conclusions and Future Directions

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

- Working with DOE/GO and Regulatory Logic, LLC, to implement the national templates for hydrogen codes and standards.
- Building the NFC4 to further consolidate and coordinate domestic and international codes and standards activities.
- Coordinating and conducting RD&D based on the Roadmap of the Codes and Standards Technical Team.
- Continuing R&D collaboration with Asia and Europe on hydrogen safety, codes, and standards.

FY 2007 Publications/Presentations

Publications

1. "Analysis of Buoyancy-driven Ventilation of Hydrogen from Buildings," D. Barley, et al., accepted by ICHS-2.
2. "Hydrogen Safety and Permitting Hydrogen Fueling Stations," J. Ohi, accepted by ICHS-2.

Presentations

1. Codes and Standards, DOE HFCIT Annual Merit Review, Washington, D.C.
2. DOE Initiative on Permitting Hydrogen Fueling Stations, Sacramento, CA.