VIII.0 Safety, Codes & Standards Sub-Program Overview

The Safety, Codes & Standards sub-program supports research and development (R&D) that provides critical information needed to define requirements and close gaps in codes and standards and safety to enable the widespread commercialization and safe deployment of hydrogen and fuel cell technologies. In Fiscal Year (FY) 2011, the sub-program focused on continuing to identify measures to reduce the risk and mitigate the consequences of potential incidents that could hinder the commercialization of these technologies.

The sub-program promotes collaboration among government, industry, codes and standards development organizations (CDOs and SDOs), universities, and national laboratories in an effort to harmonize regulations, codes, and standards (RCS) both internationally and domestically. Communication and collaboration among codes and standards stakeholders is emphasized in order to maximize the impact of the sub-program's efforts and activities in international RCS. The sub-program is leading a round-robin testing effort by the Regulations, Codes and Standards Working Group of the International Partnership for Hydrogen and Fuel Cells in the Economy (IPHE), which aims to harmonize high-pressure tank testing protocols required for tank certification. Additionally, DOE continues to work with the Department of Transportation to support its role as the U.S. representative to the United Nations ECE-WP29/GRPE to develop a global technical regulation for hydrogen-fueled vehicles.

The sub-program supports the development and implementation of best practices and procedures to ensure safety in the operation, handling, and use of hydrogen and fuel cell technologies for Program-funded projects. To achieve this goal, the sub-program utilizes the expertise of the Hydrogen Safety Panel, which evaluates the safety plans and practices of Program-funded projects. The Safety Panel provides recommendations on the safe conduct of project work as well as lessons learned and best practices that can be of broad benefit to the Program.

In addition, extensive external stakeholder input–from the fire-protection community, academia, automobile manufacturers, and the energy, insurance, and aerospace sectors–is used to create and enhance safety knowledge tools for emergency responders and authorities having jurisdiction. The sub-program has renewed its emphasis on ensuring the continual availability of safety knowledge tools, distributed via an array of media outlets to reach the largest number of safety personnel possible.

Goals

The sub-program's key goals are to provide the validated scientific and technical basis required for the development of codes and standards, to promulgate safety practices and procedures to allow for the safe deployment of hydrogen and fuel cell technologies, and to ensure that best safety practices underlie all research, technology development, and market deployment activities supported by the Hydrogen and Fuel Cells Program.

Objectives

The sub-program's key objectives are to:

- By 2015, enable development and promulgation of codes and standards essential for widespread market entry of hydrogen and fuel cell technologies, and by 2020, enable the completion and harmonization of all essential domestic and international RCS. These objectives will be achieved through:
  - Conducting R&D efforts to provide data needed to define requirements in developing codes and standards.
  - Developing and validating test measurement protocols and methods to support and facilitate international harmonization of codes and standards.
  - Coordinating with international stakeholders.
- On an ongoing basis, develop and implement practices and procedures for the safe conduct of all projects funded by the Hydrogen and Fuel Cells Program.
- On an ongoing basis, ensure that safety-related information resources and lessons learned are widely available to first responders, authorities having jurisdiction, and other key stakeholders.

FY 2011 Status

The sub-program continues to support R&D to provide the technical basis for codes and standards development with projects in a wide range of areas, including fuel specification, separation distances, materials and components compatibility, and hydrogen sensor technologies. Utilizing the results from these R&D activities, the sub-program continues to actively participate in discussions with SDOs such as the National Fire Protection Association (NFPA), International Code Council, SAE International, Canadian Standards Association (CSA), and International Organization for Standardization (ISO) to promote domestic and international collaboration and harmonization of RCS. Figure 1 gives an overview of the timeline of codes and standards development work:

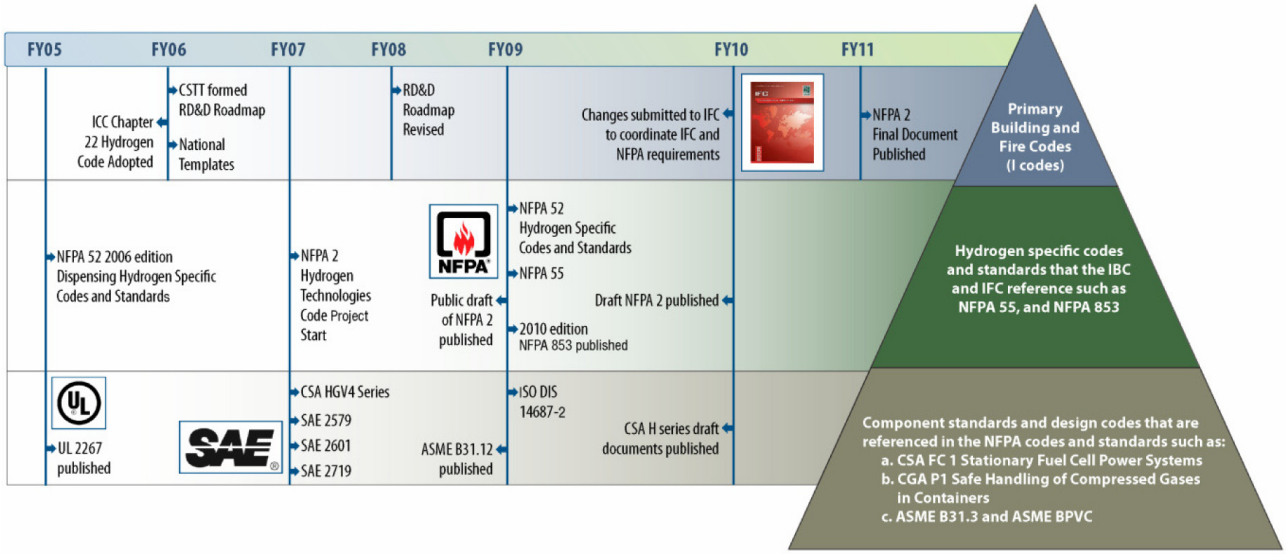


FIGURE 1. Overview of Codes and Standards Development Work

The following websites provide additional, up-to-date information relevant to the status of the sub-program's activities:

Technical Reference for Hydrogen Compatibility of Materials
http://www.ca.sandia.gov/matlsTechRef/

Hydrogen Incident Reporting and Lessons Learned Database
http://www.h2incidents.org/

Hydrogen Bibliographic Database
http://www.hydrogen.energy.gov/biblio_database.html

Hydrogen Safety Best Practices Manual
http://www.h2bestpractices.org/

Hydrogen Safety Training for Researchers
https://www-training.llnl.gov/training/hc/HS5094DOEW/index.html#

Permitting Hydrogen Facilities Compendium
http://www.hydrogen.energy.gov/permitting/

Introduction to Hydrogen for Code Officials
http://www.hydrogen.energy.gov/training/code_official_training/

Hydrogen Safety for First Responders
http://www.hydrogen.energy.gov/firstresponders.html

FY 2011 Accomplishments

Hydrogen Sensors

- Completed testing of laboratory and pre-commercial sensor prototypes, including comparison of mixed potential and impedance modality in laboratory prototypes; completed fabrication of multiple pre-commercial sensor prototype devices for testing (National Renewable Energy Laboratory [NREL]).
- Performed an assessment of hydrogen sensors and their related targets, through a Sensor Workshop, which enabled the Program to update sensor performance targets set in 2007. (Workshop attendees included representatives from industry, national laboratories, and sensor manufacturers; the workshop minutes contain updated sensor performance targets based on the comprehensive input provided by the attendees.)
- Completed round-robin testing on hydrogen sensors, in coordination with the European Commission's Joint Research Center. (Data derived from this testing, including performance, sensitivity, and reversibility was presented at the 2011 International Conference on Hydrogen Safety and validates the test approaches and methodologies.)

Fuel Quality

- Quantified the impact of fuel contaminants–for example, completed multiple tests on proton exchange membrane fuel cells under various conditions using calibrated quantities of NH_3, CO, and H_2S.
- Hydrogen fuel quality standard SAE J2719 was published. Developed and validated ASTM International techniques for measuring key constituents in the fuel.

Indoor Fueling

- Validated a model of unintended hydrogen releases and delayed ignition deflagration during indoor refueling of hydrogen-powered lift trucks. The validated model is being used in the development of requirements in NFPA 2, including specification of room volume and ventilation requirements (Sandia National Laboratories [SNL]).

Coordination of Codes and Standards Development, Domestic and International

- Harmonized and compared risk-informed approaches for the specification of separation distances in NFPA2 2011 edition codes and initiated an effort to harmonize NFPA codes with ISO 20100 codes.
- Developed procedures for performance-based pressure testing of storage vessels with gaseous hydrogen to be included in CSA HPIT1, SAE J2579, and the Global Technical Regulations Phase I (SNL).
- Held a forum on high-pressure hydrogen tanks in Beijing to identify key gaps in high-pressure vessel testing and qualification.
- Launched a new International Energy Agency (IEA) task on hydrogen safety (SNL, in partnership with Natural Resources Canada). The work plan has been approved and the initial meeting was held in Germany in April 2011. This new task (IEA Hydrogen Implementing Agreement Task 31) is a collaboration of experts from more than 12 countries.

Hydrogen Effects in Materials

- Hosted the Hydrogen Compatible Materials Workshop at SNL. Workshop participants included more than 40 international experts from industry, universities, and research laboratories. Results have been published in proceedings, which describe the prioritized research pathways for overcoming the science, engineering, and codes and standards barriers related to hydrogen compatibility with various materials. High-priority research pathways include crack initiation and crack propagation in materials in a hydrogen environment.
- Validated procedures for testing low-alloy steel materials and tanks used in lift trucks. It was found that engineering predictions of cycle-life for low-alloy pressure vessels have been lower than the actual results shown by full-scale performance testing (SNL).

- Published four additional chapters on plain carbon ferritic steels and nickel alloys in the *Hydrogen Compatibility of Materials Technical Reference*, focused on the assessment of materials compatibility for component designs and test methodologies.

Hydrogen Safety Panel

- The Hydrogen Safety Panel reviewed 60 safety plans for projects within the Program's R&D portfolio and American Recovery and Reinvestment Act-funded fuel cell deployments. Panel teams conducted safety review site visits for four Program-funded projects and participated in a 30% design review of the new Energy Systems Integration Facility at NREL (Pacific Northwest National Laboratory).
- Six project safety evaluation reports were issued. Overall results for these safety evaluations indicate that over 90% of report recommendations have been voluntarily completed or are well in progress.
- New content was added to the *Hydrogen Safety Best Practices Manual* for the following topics: hydrogen properties focusing on combustion and liquid hydrogen expansion; the indoor refueling of hydrogen fuel cell–powered forklifts; and chemical hydrogen storage. A new section, "So You Want to Know Something about Hydrogen," was created as a resource for students, technicians, and young engineers less familiar with hydrogen.
- The Hydrogen Incident Reporting and Lessons Learned Database added 56 new records from national laboratories, universities, and private-sector firms in the U.S. and other countries.

First Responders

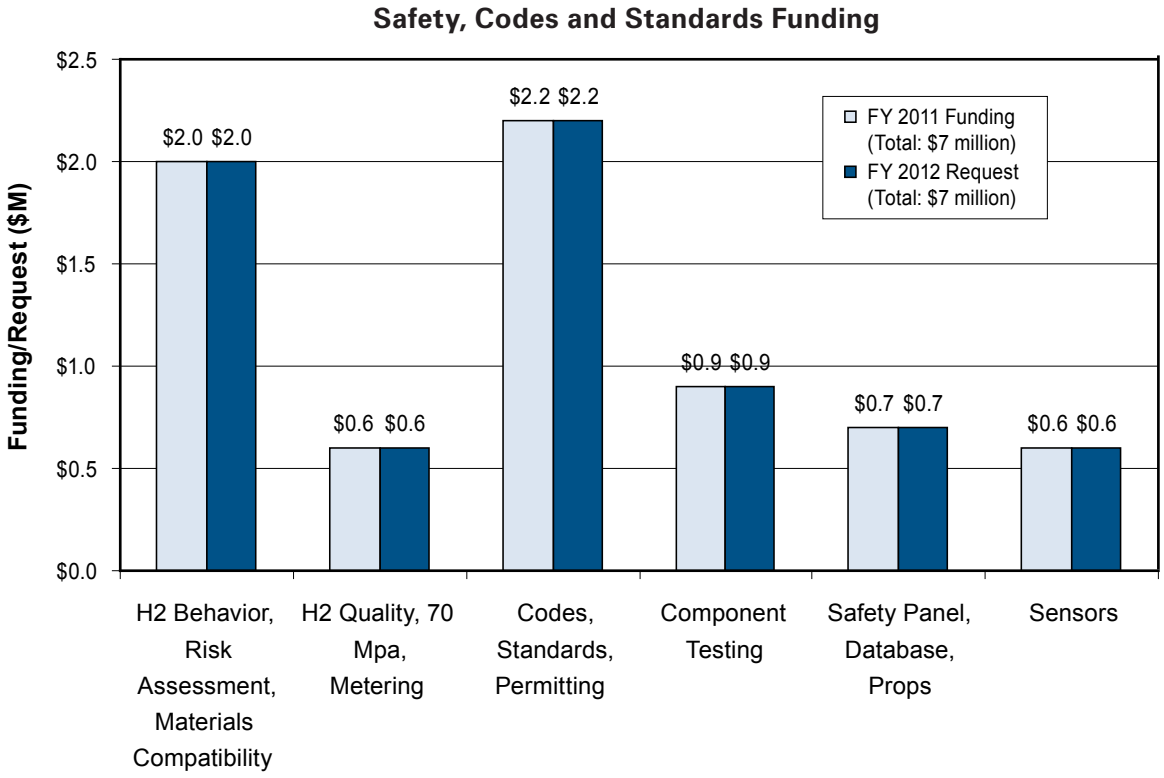
- The operations-level, prop-based course, Hydrogen Emergency Response Training for First Responders, was conducted at the Department of Defense's Defense Logistics Agency (DLA) near Tracy, California, where hydrogen fuel cell–powered forklifts are being used. Six one-day classes were conducted over a two-week period at the DLA's San Joaquin sites. To-date, approximately 350 first responders from 18 states have completed this course.

Education and Outreach

- Conducted Codes and Standards workshop in Anaheim, California, in collaboration with the Southern California Fire Protection Officers Association and the California Fuel Cell Partnership. Attendees included fire service members from at least seven key jurisdictions in the Los Angeles metropolitan area.

Budget

The sub-program received an appropriation of $7.0 M in FY 2011. This allowed for sustained progress in key R&D and codes and standards development work. The President's FY 2012 budget request includes $7.0 M for safety, codes and standards, which will ensure continuity in key R&D and focus areas as shown in the following figure.



FY 2012 Plans

The Safety, Codes & Standards sub-program will continue to work with codes and standards organizations to identify and address needs for the development of new hydrogen-specific codes and standards. To address these challenges, the sub-program will continue to support its rigorous technical R&D program.

In FY 2012 and beyond, the sub-program will continue to focus on critical safety R&D, such as assessment of materials compatibility for component designs, high-pressure tank cycle testing, and promoting a quantitative risk assessment approach to ensure the development of technically sound codes and standards. The sub-program will continue to promote the domestic and international harmonization of RCS by working with the appropriate domestic and international organizations such as NFPA, International Code Council, SAE International, CSA, and the ISO. The sub-program will continue to participate in the IPHE's Regulations, Codes and Standards Working Group and the IEA's Hydrogen Implementing Agreement, both of which have been engaged in hydrogen safety work.

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