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

INTRODUCTION

The Safety, Codes and Standards sub-program identifies research and development (R&D) needs and performs high priority R&D to provide an experimentally validated fundamental understanding of the relevant physics, critical data, and safety information needed to define the requirements for technically sound and defensible codes and standards. This information is used to facilitate and enable the widespread deployment and commercialization of hydrogen and fuel cell technologies. In Fiscal Year (FY) 2015, the Sub-Program continued to identify and evaluate safety and risk management measures that can be used to define the requirements and close the gaps in codes and standards in a timely manner.

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, the federal government, industry, national labs, and trade associations are emphasized in order to maximize the impact of the sub-program's efforts and activities in international RCS development.

The sub-program has achieved accomplishments in R&D for codes and standards support. In FY 2015, the Hydrogen Risk Assessment Models (HyRAM) were released for alpha testing by various stakeholders, including industry representatives. This software enables quantitative risk assessment (QRA) and performance-based design, and incorporates hydrogen behavior models also developed through the sub-program. A model for release of liquid hydrogen was validated and will be used, along with the QRA tool, to inform separation distances in the 2019 code cycle for National Fire Protection Association (NFPA) 2/55. Development continues for a hydrogen contaminant detector with demonstrated sensitivity to both carbon monoxide (CO) and hydrogen sulfide (H_2S) at Society for Automotive Engineers (SAE) J2719 levels. In addition, the Continuous Codes and Standards Improvement (CCSI) process was initiated, allowing learnings from field deployment to inform code and standard development. One example of CCSI is an NFPA 2/55 task group that was formed to examine the setback distances for both gaseous and liquid hydrogen and to consider possible mitigation strategies that could be implemented to reduce setback distance requirements. Finally, the sub-program is working to support station deployment through utilizing alternative code compliance methods such as those found in NFPA Chapter 5.

The sub-program continues to utilize the expertise of the Hydrogen Safety Panel (HSP) to disseminate relevant information and implement safe practices pertaining to the operation, handling, and use of hydrogen and fuel cell technologies in sub-program-funded projects. HSP, with over 400 years of combined experience in the hydrogen industry, provides recommendations on the safe conduct of Federally-funded project work as well as lessons learned and best practices that can be of broad benefit to the sub-program. The sub-program continues to share current safety information and knowledge with the community through the launch of H2Tools.org, which, in addition to consolidating existing resources (i.e., Hydrogen Lessons Learned Database), serves as a centralized resource for hydrogen safety information, news, and user-specific content.

In addition, extensive external stakeholder input from the fire-protection community, academia, automobile manufacturers, and energy, insurance, and aerospace sectors, is used to create and enhance safety knowledge tools for emergency responders and authorities having jurisdiction (AJHs). 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. During FY 2015, the sub-program's training for code officials and first responders reached more than 35,000 individuals through our online and classroom trainings.

GOAL

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 are followed in Fuel Cell Technologies Office activities.

OBJECTIVES

The sub-program's key objectives are to:

- Support and facilitate development and promulgation of essential codes and standards to enable widespread deployment and market entry of hydrogen and fuel cell technologies and completion of all essential domestic and international RCS.
- Conduct R&D to provide critical data and information needed to define requirements in developing codes and standards.
- Ensure that best safety practices underlie research, technology development, and market deployment activities supported through DOE-funded projects.
- Develop and enable widespread sharing of safety-related information resources and lessons learned with first responders, AHJs, and other key stakeholders.

FY 2015 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 NFPA, the International Code Council (ICC), SAE International, the CSA Group, and the International Organization for Standardization (ISO) to promote domestic and international collaboration and harmonization of RCS.

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

- H2Tools (http://h2tools.org/)
  The following resources are available on the H2Tools.org site.
  - Technical Reference for Hydrogen Compatibility of Materials (www.ca.sandia.gov/matlsTechRef/ also available at https://h2tools.org/tech-ref)
  - Hydrogen Lessons Learned Database (https://h2tools.org/lessons)
  - Hydrogen Bibliographic Database (https://h2tools.org/bibliography)
  - Hydrogen Safety Best Practices Manual (https://h2tools.org/bestpractices)
  - National Hydrogen and Fuel Cell Emergency Response Training Resource (https://h2tools.org/fr/nt)
- Hydrogen Safety Training for Researchers (www.h2labsafety.org)
- Introduction to Hydrogen for Code Officials (www.hydrogen.energy.gov/training/code_official_training/)
- Hydrogen Safety for First Responders (www.hydrogen.energy.gov/firstresponders.html)

FY 2015 KEY ACCOMPLISHMENTS

The sub-program continued to make progress in several key areas, including the following.

Hydrogen Behavior, Risk Assessment, and Materials Compatibility (Sandia National Laboratories)

- Released HyRAM v1.0 for alpha testing by industry stakeholders; HyRAM is a first-of-its-kind software tool that enables quantitative risk assessment through reliability data and engineering models and includes a physics mode
- Developed a template of a viable performance-based design (PBD) approach to code compliance that facilitates industry use, AHJ acceptance, and leads to improved PBD requirements in the codes
- Initiated new capability for testing hydrogen embrittlement of stainless steels at sub-ambient temperature

Hydrogen Quality (Los Alamos National Laboratory [LANL])

- Demonstrated sensitivity to CO and H_2S at SAE J2719 levels (0.2 ppm and 4 ppb, respectively) with detection within minutes

Coordination of Codes and Standards Development, Domestic and International (National Renewable Energy Laboratory [NREL])

- Formed a group of code experts through the Fuel Cell Hydrogen Energy Association's Transportation Working Group called the Hydrogen Code Improvement team to address gaps between the International Code Council (I-codes) and NFPA 2
- Developed a plan to revise the liquid hydrogen setback distances in NFPA 2/55 and develop a process for converting mitigation measures into reduced setback distances

Component Testing (NREL)

- Developed a test apparatus for pressure relief valves
- Demonstrated repeatable operation of temperature cycling for accelerated life cycle testing of components

Hydrogen Safety Panel, Databases, Props, and First Responders (Pacific Northwest National Laboratory [PNNL])

- H2Tools.org was launched, consolidating existing safety and knowledge resources into a central location alongside newly added functionality and content.
- PNNL released National Hydrogen and Fuel Cell Emergency Response Training Resource, which is a regularly updated, downloadable resource that allows training for first responders on a local basis with consistent information.
- HSP continues to support best hydrogen safety practices, with 18 project reviews in the past year and supporting state initiatives. HSP's 2013 white paper, "Safety of Hydrogen Systems Installed in Outdoor Enclosures," supported new prescriptive requirements for hydrogen equipment enclosures in the 2016 version of NFPA 2.

Hydrogen Sensors (NREL and LANL)

- Validated hydrogen leak sensor in real-world station environment; investments since 2008 have turned the LANL/Lawrence Livermore National Laboratory-developed solid state electrochemical safety sensor into a commercially ready technology with sensitivity better than commercially available technologies (LANL)
- Developed a test apparatus for verifying tailpipe hydrogen emissions and initiated testing; demonstrated sampling rate of four times per second with accurate readings at low gas levels (NREL)

BUDGET

The sub-program received an appropriation of $7 million in FY 2015 (Figure 1). This allowed for sustained progress in key R&D and codes and standards development work. The President's FY 2016 budget request includes $7 million for Safety, Codes and Standards, which will ensure continuity in key R&D and focus areas as shown below. The R&D category includes such activities as hydrogen behavior, risk assessment and mitigation, materials compatibility, hydrogen fuel quality, metering, sensors, and component testing. The safety management and resources category includes the Hydrogen Safety Panel, databases, training, and training materials. The outreach category includes codes and standards, permitting, continuous codes and standards improvement, and resource dissemination.

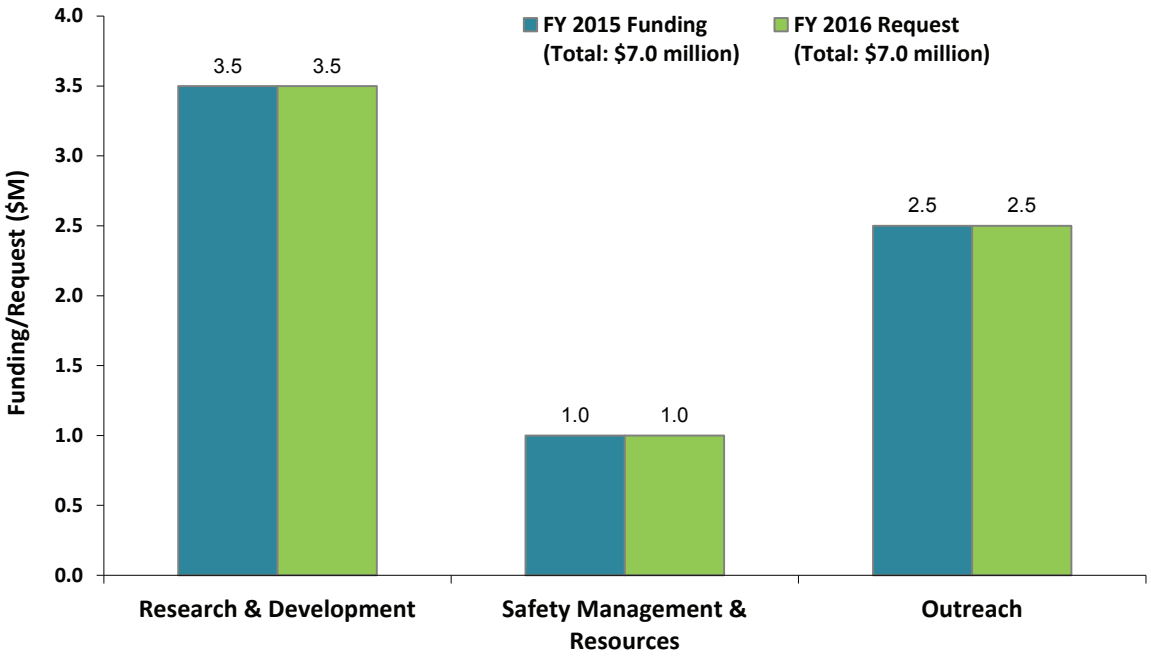

FIGURE 1. Safety, Codes and Standards R&D Funding. Subject to appropriations, project go/no-go decisions, and competitive selections. Exact amounts will be determined based on research and development progress in each area and the relative merit and applicability of projects competitively selected through planned funding opportunity announcements.

FY 2016 PLANS

The Safety, Codes and Standards sub-program will continue to work with CDOs and SDOs to develop technical information and performance data to enhance hydrogen-specific codes and standards. To address these needs, the sub-program will continue to support rigorous technical R&D, including assessment of materials compatibility for component designs and high pressure tank cycle testing, and continue to promote a performance-based QRA approach to assess risks and establish protocols to identify and mitigate risk. Future work will also focus on facilitating the permitting of hydrogen fueling stations and early market applications and testing, measurement, and verification of hydrogen fuel specifications.

The sub-program will continue to promote the domestic and international harmonization of test protocols for qualification and certification as well as the harmonization of RCS for hydrogen fuel quality and other key international standards. This will be enabled by working with the appropriate domestic and international organizations such as the NFPA, ICC, SAE International, the CSA Group, and ISO. The sub-program will also continue to participate in the International Partnership for Hydrogen and Fuel Cells in the Economy's RCS Working Group and the International Energy Agency's Hydrogen Implementing Agreement, both of which are engaged in hydrogen safety work.

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