VIII.0 Safety, Codes & Standards Program Overview

INTRODUCTION

The Safety, Codes and Standards 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) 2016, the 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 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 is emphasized in order to maximize the impact of the program's efforts and activities in international RCS development.

The program has achieved accomplishments in R&D for codes and standards support. In FY 2016, the Hydrogen Risk Assessment Model (HyRAM) version 1.0 was released for public use and is available to download online[1]. In addition, a new cryogenic hydrogen release laboratory was constructed, and planned releases will help inform separation distances for liquid hydrogen. The program continues to advance its materials work by conducting fatigue testing in Cr-Mo steels, populating a database with materials-in-hydrogen properties, and initiating a new project on hydrogen compatibility of non-metallic materials. Furthermore, in the area of fuel quality assurance, a prototype in-line fuel quality analyzer was developed. These R&D accomplishments feed into the program's Continuous Codes and Standards Improvement process, which submitted revised bulk gaseous hydrogen separation distances for consideration to National Fire Protection Association (NFPA) 2/55.

The program continues to utilize the expertise of the Hydrogen Safety Panel to disseminate relevant information and implement safe practices pertaining to the operation, handling, and use of hydrogen and fuel cell technologies in program-funded projects. The program also continues to share current safety information and knowledge with the community through the continued development of resources for H2Tools.org. The program continues to place emphasis on ensuring the continual availability of safety knowledge tools, to reach the largest number of safety personnel possible. During FY 2016, the program's training for code officials and first responders has reached more than 36,000 individuals through on-line and classroom training.

GOAL

The 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 Hydrogen and Fuel Cells Program activities.

OBJECTIVES

The 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.

[1] http://energy.sandia.gov/transportation-energy/hydrogen/quantitative-risk-assessment/hydrogen-risk-assessment-model-hyram/

- Develop and enable widespread sharing of safety-related information resources and lessons learned with first responders, authorities having jurisdiction, and other key stakeholders.

FY 2016 STATUS AND ACCOMPLISHMENTS

The program continues to support R&D to provide the scientific basis for codes and standards development, with projects in fuel specification, separation distances, materials and components compatibility, and hydrogen sensor technologies. Utilizing the results from these R&D activities, the program continues to actively participate in discussions with SDOs such as the NFPA, the International Code Council, SAE International, the CSA Group, and the International Organization for Standardization (ISO) to promote domestic and international collaboration and harmonization of RCS.

The H2Tools website (http://h2tools.org/) provides additional, up-to-date information relevant to the status of the program's activities. Resources available on the H2Tools.org site include the Technical Reference for Hydrogen Compatibility of Materials, the Hydrogen Lessons Learned Database, the Hydrogen Bibliographic Database, the Hydrogen Safety Best Practices Manual, the National Hydrogen and Fuel Cell Emergency Response Training Resource, Hydrogen Safety Training for Researchers, the Introduction to Hydrogen for Code Officials, Hydrogen Safety for First Responders, and Codes and Standards – Permitting Tools, including the National Permitting Guide. This year, the National Hydrogen and Fuel Cell Emergency Response Training Resource was also translated into Japanese. The H2Tools website continues to see increasing traffic, with ~10,000 visits as of May 2016, many of which are international visits.

The Program continued to make progress in several key areas, including the following:

- Hydrogen Behavior, Risk Assessment (Sandia National Laboratories):
  - Completed design, construction, and commissioning of the cryogenic liquid hydrogen release laboratory to enable advanced diagnostic studies of cryogenic hydrogen releases.
  - Publicly released a free version of Hydrogen Risk Assessment Models (HyRAM) V1.0 software for risk analysis of hydrogen infrastructure systems, including modules for simulating gas plume dispersion, overpressure, and layering behavior from user-defined releases, as well as engineering tools such as simple hydrogen safety calculations (e.g., thermodynamic conversions and mass flow rate calculations).
  - Calculated revised bulk gaseous separation distances using modified risk criteria for adoption by the NFPA 2/55 technical committees, which will enable more sites to readily accept hydrogen infrastructure. These changes demonstrated the potential for up to an additional 50% reduction in gaseous hydrogen separation distances over previous code requirements.
- Materials Compatibility (Sandia National Laboratories, Pacific Northwest National Laboratory, Oak Ridge National Laboratory):
  - Completed fatigue initiation testing of Cr–Mo steel specimens provided by the Fuel Cell Hydrogen Joint Undertaking's MATHRYCE project at two hydrogen gas pressures (30 and 100 MPa). Results show that the number of cycles for crack initiation decreases as hydrogen pressure increases from 30 to 100 MPa, confirming that fatigue testing at 30 MPa is non-conservative relative to a service pressure of 100 MPa.
  - Compiled input from over 50 hydrogen infrastructure stakeholders on polymers of interest, current utilized test methods, operating conditions, and applications to identify knowledge gaps for hydrogen compatibility with polymeric materials. Stakeholders included hydrogen system designers, component manufacturers, polymer producers, code committee members, and hydrogen suppliers. Initiated testing of selected materials.
- Hydrogen Quality (Los Alamos National Laboratory):
  - Developed a prototype in-line hydrogen fuel quality analyzer with a hydration scheme that allows for constant baseline measurements.
  - Measured the fuel cell response to 50 ppm CO (limited only by the lag time of the system) in hydrogen after switching from neat hydrogen. To date, this was the fastest response time (<< 1 min) obtained, although the CO concentration was much higher than the SAE/ISO limit.

- Coordination of Codes and Standards Development, Domestic and International, and Codes and Standards Outreach (Sandia National Laboratories, National Renewable Energy Laboratory, Oak Ridge National Laboratory):
  - Managed the development of numerous draft public inputs to NFPA 2, NFPA 55, and the International Fire Code, with the aim of addressing key industry needs, including for fuel cell electric vehicle repair booths and harmonized requirements for defueling, and of addressing inconsistencies or lack of clarity between model codes.
  - Developed a training video titled "Permitting Hydrogen Fueling Stations" in collaboration with an authority having jurisdiction in the Los Angeles metropolitan area and the Orange County Fire Authority, where several hydrogen fueling stations will be located. This video should reduce the time and cost of both preparing and processing hydrogen fueling station permit applications by quickly orienting people to both the basics of the fueling technology and the code requirements.
- Hydrogen Safety Panel, Databases, Props, and First Responders (Pacific Northwest National Laboratory):
  - Led a team of four first responders from the United States to participate in the European Hydrogen Emergency Response Training Program for First Responders (HyResponse), held at L'École Nationale Supérieure des Officiers de Sapeurs-Pompiers (ENSOSP) (The French Academy for Fire, Rescue, and Civil Protection Officers) in Aix en Provence, France, May 9–13, 2016.
  - Added additional resource tools for codes and standards permitting, Hydrogen Fueling Infrastructure Research and Station Technology (H2FIRST), and the Hydrogen Station Equipment Performance (HyStEP) device to the Hydrogen Tools Portal (http://h2tools.org).
- Hydrogen Sensors (National Renewable Energy Laboratory & Los Alamos National Laboratory):
  - Quantified the impact of potential chemical poisons, as identified in ISO 26140, on the major hydrogen sensor platform types in collaboration with the Joint Research Centre Institute for Energy and Transport.
  - Formed a group among the National Renewable Energy Laboratory and the Joint Research Centre sensor experts with computation fluid dynamics modelers and risk assessment experts to provide guidelines on hydrogen sensor placement for various facilities (e.g., maintenance repair) that will contain hydrogen.

BUDGET

The program received an appropriation of $7 million in FY 2016 (Figure 1). FY 2016 funding has allowed for continued support of codes-and-standards-related R&D and of the domestic and international collaboration and harmonization efforts for codes and standards that are needed to support the commercialization of hydrogen and fuel cell technologies. The FY 2017 request of $10 million will allow the program to broaden its existing R&D efforts and expand its focus to include infrastructure-related activities. The "Research and Development" 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 props. The "Outreach" category includes codes and standards, permitting, continuous codes and standards improvement, and resource dissemination.

FY 2017 PLANS

The Safety, Codes and Standards 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 program will continue to support a rigorous technical R&D program—including assessment of materials compatibility for component designs and high-pressure tank cycle testing—and continue to promote a performance-based quantitative risk assessment approach to assess risks and establish protocols to identify and mitigate risk. A major focus will be R&D to inform appropriate revised separation distance requirements for liquid hydrogen installations. 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 program will also 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

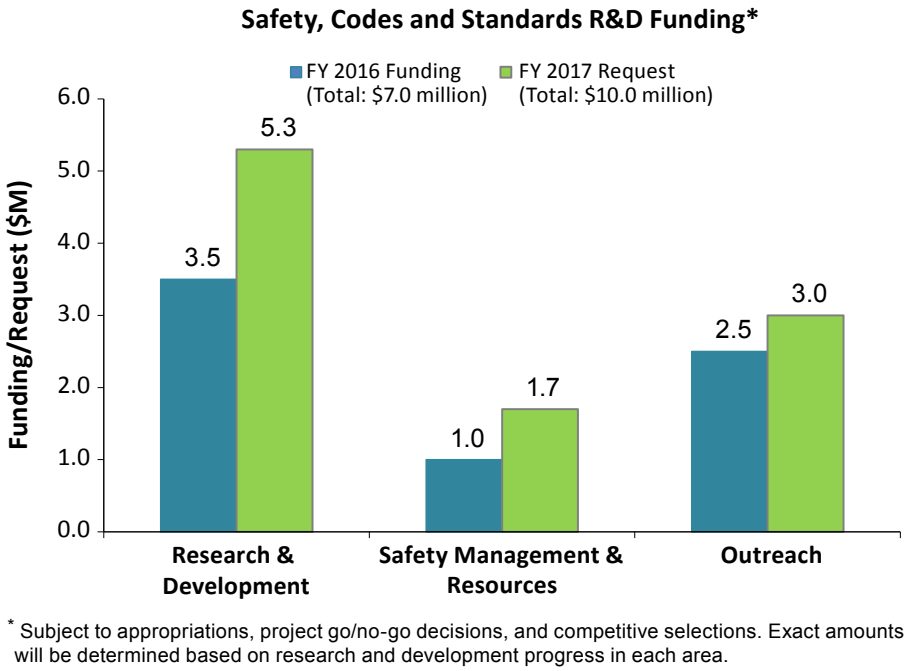

FIGURE 1. FY 2016 appropriations and FY 2017 budget request for the Safety, Codes and Standards program

international standards. These efforts will be enabled by working with the appropriate domestic and international organizations such as the NFPA, International Code Council, SAE International, the CSA Group, and the ISO. For the first time, the Safety, Codes and Standards program is collaborating with the Federal Energy Management Program to develop hydrogen safety training materials utilizing existing training resources. The 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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