2.2.6 HYDROGEN INFRASTRUCTURE SAFETY

Technology Description

Similar to other commodities used as fuels in today's energy and transportation systems, hydrogen is classified as a hazardous material. Direct transport and storage of hydrogen can be achieved via pipelines, compressed gas storage vessels/cylinders, cryogenic vessels, as a hydride, or contained in a nanostructured material. Other commodities, including natural gas and methanol, also can be used as hydrogen carriers that are later reformed. Extensive hydrogen infrastructure is already in place to meet the transport needs of the petrochemical, fertilizer, electronics, and food industries. The approach to safely expand the hydrogen infrastructure is expected to build on current delivery approaches. Federal agencies are working to test and refine existing hydrogen technologies in compliance with Federal standards while developing new technologies that can improve hydrogen distribution, as well as reduce or eliminate leaks or other risks. Codes and standards must be adopted that support the safe, commercialization and integration of these technologies into the existing transportation and energy infrastructures of the United States.

System Concepts and Representative Technologies

- There are currently three primary methods of hydrogen transport and storage: pipeline, vehicular commodity transport via tube-trailer/pressure vessels and cryogenic vessels, and stationary/fixed storage and fueling infrastructure.
- Within the United States, each of the three primary methods of hydrogen transport and storage is governed by a different set of regulations established by The U.S. Department of Transportation (DOT)/Pipeline and Hazardous Materials Safety Administration (PHMSA) and local and state fire marshals.
- The current system for transporting natural gas and hydrogen provides a reasonable foundation and model for expanding the hydrogen infrastructure. However, the current paradigm, with the exception of motor fuels and natural gas, is for hazardous materials (HAZMAT) transport to divert or restrict the transport of these materials into urban areas and through tunnels and other vulnerable transportation infrastructure.
- Current technologies include: small diameter hydrogen pipelines; DOT-approved pressure vessels and cylinders; DOT-approved cryogenic vessels; and, for stationary applications, pressure vessels complying with the American Society of Mechanical Engineers (ASME) boiler and pressure vessel code.
- New technologies developed or being proposed include very high-pressure (13,000-15,000 psi), all-composite pressure vessels meeting both DOT and ASME requirements; advanced pipeline materials that reduce and/or catalyze permeated or leaked hydrogen; hydrides; below-ground cryogenic vessels; and nanostructured materials.
- These new technologies may be additions to or replace current transportation infrastructure, or may be integrated into the existing infrastructure.

Technology Status/Applications

- Hydrogen has been transported and stored within the United States safely, securely, and reliably, for several decades using the current conventional (under 4,500 psi) technologies.
- New technologies to increase the efficiency and reduce the cost of hydrogen transport, such as advanced carbon composite cylinders and storage, are being adapted. New technologies are being reviewed and evaluated within the framework of the appropriate and necessary Federal regulations and other codes and standards.
- Other technologies, such as carbon nanotubes and advanced pipeline materials, are still in an early research and development (R&D) phase and are not ready for commercialization.
- The DOT/ Pipeline and Hazardous Materials Safety Administration (PHMSA) is currently reviewing applications for exemption for several technologies, including hydrides and high-pressure composite cylinder mobile fuelers, and is working with industry and the Department of Energy (DOE) to help guide safe and successful development and deployment of these technologies.

Current Research, Development, and Demonstration

RD&D Goals

- Work within the Federal government to develop, test, and approve new hydrogen storage and monitoring technologies.

- Conduct a thorough and comprehensive transportation and storage hydrogen infrastructure assessment to address capacity, safety, security, reliability, operations, and environmental compliance evaluating scenarios for near-term and long-term development and implementation of hydrogen infrastructure including a risk analysis for each technology and application.
- Investigate future systems that offer improved safety, security, reliability, and functionality vs. the current transportation and storage systems.

RD&D Challenges

- Gain a fundamental understanding of fatigue and failure modes of hydrogen materials including advanced composites and other storage media.
- Establish effective monitoring, inspection, and recertification technologies and procedures for hydrogen transport and storage.
- Adapt aging infrastructure to accommodate new demands.
- Educate and train operators, regulators, and users effectively.

RD&D Activities

- The overall strategy of the HFCIT Program is to conduct a comprehensive and balanced program that includes mid- and long-term research and development of hydrogen production, storage, and utilization technologies; integrated systems and technology validation using close collaboration with industry that develops, demonstrates, and deploys critical technologies emerging from research and development; and an analysis element that helps determine the performance and cost targets that technologies must meet to achieve goals of the HFCIT Program, as well as specific project objectives determined by peer review.
- DOE's HFCIT Program is carried out by national laboratories, universities, and the private sector, including cost-shared industry-led efforts; d CRADA collaborations between industry and the labs.

Recent Progress

- To address the key barrier of perceived safety, the DOE initiated a successful effort to have the International Code Council (ICC) form a special committee to develop provisions specific to hydrogen for incorporation into its model building, fire, and fuel gas codes, which the ICC will publish for adoption by local jurisdictions throughout the United States. The ICC model codes will incorporate standards for hydrogen components and equipment being developed by leading organizations, such as the Society of Automotive Engineers and the International Standards Organization.
- Six chapters of a planned 15 chapters on hydrogen materials have been published on-line detailing properties of hydrogen materials and embrittlement.
- Through a consensus workshop process, a path forward has been established to integrate risk assessment analysis into the codes and standards process.
- Progress is being made in the development and revision of consensus codes and standards. Numerous draft standards are currently under review and adoption process. Excellent progress has been made in establishing an international hydrogen fuel-quality specification.

Commercialization and Deployment Activities

- Through its regulatory authority, DOT supports deployment and demonstration of pipelines and vehicles.
- The Operating Administrations of DOT, specifically the Pipeline and Hazardous Materials Safety Administration (PHMSA) and the National Highway Traffic Safety Administration (NHTSA), are actively engaged in domestic and international consensus codes and standards development.
- DOT staff support DOE R&D activities and the activities and committees of the various consensus codes- and standards-setting organizations.
- DOT staff continues to work with the National Association of State Fire Marshals to educate and train personnel and to promote safe handling and storage practices.