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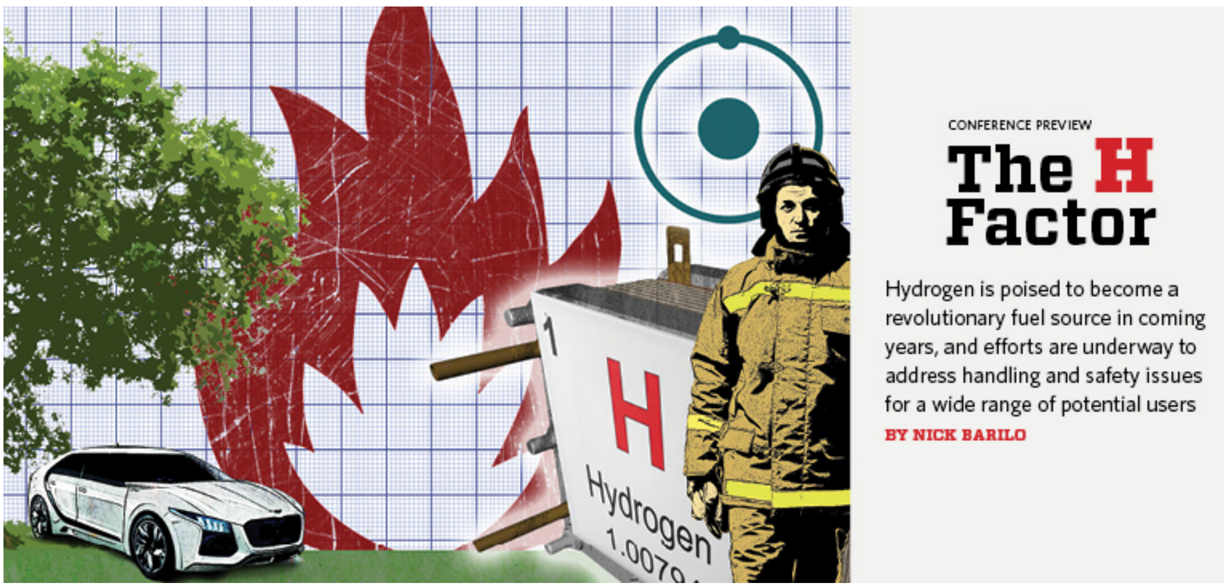

. Author(s): Nick Barilo. Published on May 2, 2014.

AS THE WORLD SEEKS TO IDENTIFY alternative energy sources, hydrogen-powered fuel cells offer a broad range of benefits for the environment, the economy, and energy security. Hydrogen fuel cells have the potential to replace the internal combustion engine and to provide power in a wide range of stationary and portable applications.

In vehicles, for example, hydrogen holds the potential for revolutionizing our fuel sources. Fuel cells - technology that can convert the chemical energy of a fuel, in this case hydrogen, into electricity - are poised to enter the transportation sector, where major automobile manufacturers plan to make fuel cell vehicles available to the public beginning this year. To support the deployment of these vehicles, hydrogen fueling stations - either standalone or as part of conventional gasoline dispensing facilities - will be needed. Among the early markets realizing the benefits of fuel cells are warehousing operations, where fuel cells are currently replacing battery-powered industrial trucks. It is anticipated that commercialization of consumer fuel cell vehicles by major auto manufacturers will launch in California starting this year.

Vehicles aren't the only area where hydrogen is gaining ground; the list of applications is growing as a variety of sectors recognize the value and benefit of this technology.

Those uses include telecommunications facilities, where fuel cells deliver backup power to cell towers; commercial and industrial buildings, where fuel cells provide primary and backup power; and in the transportation of perishable goods, where refrigeration equipment powered by fuel cells is being developed as an alternative to traditional diesel auxiliary power units.

Hydrogen has long been an ingredient in many industrial processes, and can be handled and used safely with the appropriate practices and engineering measures in place. Its use as a fuel is still relatively new, though, and the proper methods of handling, storage, transport, and use are often not well understood across the various communities that either participate in or are impacted by its demonstration and deployment.

Hydrogen is a flammable gas at atmospheric conditions and diffuses rapidly in air and through materials not normally considered porous. When mixed with air at concentrations of 4 percent to 75 percent, it forms a flammable mixture that requires only a small amount of energy for ignition and burns with a pale blue, almost invisible flame. Its flammability is in part why the deployment of hydrogen for commercial and public use necessitates the development, dissemination, and implementation of hydrogen safety standards and practices, among them NFPA 2, Hydrogen Technologies Code, which was introduced in 2011.

Safety concerns include hydrogen fuel pumps for vehicles.

NFPA's involvement goes beyond the creation of a hydrogen standard. To support the provisions of NFPA 2, the Fire Protection Research Foundation has participated in a range of work involving hydrogen, available at nfpa.org/foundation. Additionally, NFPA's Electric Vehicle Safety Training project, a program to help firefighters and other emergency responders prepare for the growing number of electric, hybrid, and alternative-fuel vehicles on the road, includes training in hydrogen fuel cell safety.

A pair of education sessions at the Conference & Expo will address some of these topics. "Hydrogen and Fuel Cell Projects: Integrating Safety From Design to Operation" will identify the activities, codes and standards, and resources for integrating safety into these projects, and "Hydrogen and Fuel Cell Vehicles: Educating Emergency Responders" will describe a program developed to educate first responders about hydrogen, hydrogen fuel cell applications, hydrogen transportation, and fueling infrastructure, as well as how the program is being structured for use as a national training template.

Elemental element

The discussion of hydrogen safety isn't new. To help develop and disseminate safe practices, the Hydrogen Safety Panel was established in 2003 to support the U.S. Department of Energy's efforts to commercialize fuel cell technologies. The 13-member panel is comprised of a cross-section of expertise from the commercial, industrial, government, and academic sectors. It seeks to identify safety-related technical data gaps, best practices, and lessons learned, and to help integrate safety planning into hydrogen and fuel cell projects to ensure that the appropriate safety practices are addressed and incorporated.

The panel's project-related activities include the review of equipment and facility designs, evaluating risk assessments and safety plans, and conducting site safety reviews. These reviews of hydrogen technology deployment also support the panel's related efforts to identify safety-related technical data gaps in the development of codes and standards, and to support the dissemination of safety knowledge.

The panel's most recent work has focused on commercial demonstration projects to accelerate the commercialization and deployment of fuel cells. These early market applications include vehicle fueling, material handling equipment, backup power for warehouses and telecommunication sites, and portable power devices. The panel's work has helped identify knowledge gaps that warrant further consideration, two of which are the application of codes and standards to outdoor enclosures housing hydrogen equipment and the need to certify equipment.

Adherence to codes and standards is essential for ensuring public safety and confidence in commercial enterprises, particularly for those deploying new technologies. With the increased interest in hydrogen as a fuel source, the NFPA Standards Council was petitioned in 2005 to develop an all-encompassing document establishing requirements for hydrogen technologies. The first edition of NFPA 2 was primarily developed from existing NFPA codes and standards, including NFPA 52, Vehicular Gaseous Fuel Systems; NFPA 55, Compressed Gases and Cryogenic Fluids; and NFPA 853, Installation of Stationary Fuel Cell Power Systems. NFPA 2 is meant to provide a single resource to support the design and approval of hydrogen equipment and facilities.

Resources for emergency responders

- NFPA training on electric and alternative-fuel vehicles for emergency responders
- Introduction to hydrogen safety for first responders
- Hydrogen emergency response training for first responders
- Information on the California Fuel Cell Partnership
- "Reaching the U.S. Fire Service with Hydrogen Safety Information: A Roadmap," a report by the Fire Protection Research Foundation

A significant change occurred when the 2013 version of NFPA 52 transferred the responsibility for hydrogen vehicle fueling requirements to the NFPA 2 technical committee; starting with the 2016 version, NFPA 2 will be the only source for this information. NFPA 2's significance will likely grow since approved changes to the 2015 edition of NFPA 1, Fire Code, and the International Fire Code will directly refer to NFPA 2 for hydrogen vehicle fueling facility requirements. As we continue through the revision cycle for the 2016 edition of NFPA 2, some of the central issues being addressed by the technical committee include establishing requirements for equipment enclosures and repair garages and refining the requirements for gaseous vehicle fueling and hydrogen generation systems.

Observations from the Hydrogen Safety Panel's review of early market applications revealed challenges faced in applying NFPA requirements to hydrogen systems installed in outdoor enclosures. The enclosures vary in size; they can be small boxes (6 to 16 square feet, containing cylinders with a total capacity of 1,000 to 8,000 cubic feet of hydrogen) used to supply fuel cell stationary power systems, or they can be large intermodal containers (160- to 320-square-foot shipping containers) housing generation, compression, storage, and dispensing equipment with personnel access. These enclosures could include spaces where a flammable mixture of hydrogen and air might accumulate near an ignition source, creating the potential for a fire or explosion. If the enclosure is large enough for a person to enter and ventilation is inadequate, the hydrogen concentration could present an asphyxiation hazard.

Except for structures like large intermodal containers that might be considered buildings, there is no consistent set of requirements governing the construction of enclosures, ventilation systems, leak or fire detection systems, electrical classification, and separation distances between the enclosure and other structures or equipment. And while such large containers might be considered a building by many code officials, interpretations by regulators can vary widely, leading to the inconsistent application of rules. Without clear requirements for the different types of enclosures, designers have little guidance on how to design safe systems, and code officials have difficulty determining which code requirements may apply to which enclosures.

The certification challenge

The certification of equipment is another need identified by the panel during its review of fuel cell deployment projects. NFPA's definition of certification includes "a system whereby a certification organization determines that a manufacturer has demonstrated the ability to produce a product that complies with the requirements of a specific standard(s)." Codes and standards will then supplement this topic with use of the related terms "approved, listed, and labeled." Each term purposely has a slightly different meaning that relates to some level of formalized compliance by a third party or, in the case of the term "approved" something that is deemed acceptable to the authority having jurisdiction (AHJ). These terms can apply to individual components or, more broadly, to systems or an entire assembly.

At the moment, though, the certification process suggested by the panel presents significant challenges. What the panel considers "certification" is likely to cause confusion with terminology used in the various NFPA codes and standards. There may be difficulties applying certification standards or even the absence of such standards, as well as a lack of certification organizations. The certification process for rapidly changing products consistent with developing technologies may also be cost-prohibitive, and there is a need to clarify what a certification covers relative to a particular piece of equipment, system, assembly, or facility.

Concerns have also been raised by panel members regarding third-party certification, which will likely be critical to the long-term success of commercialization of hydrogen fuel cell systems. Panel members have pointed out that the scarcity of third-party certification places an extraordinary burden on fuel cell providers to ensure that their products include the appropriate inherent or automatic safety measures. When fuel cells and certification processes become more widespread, it will be important to ensure that third-party product certification or listing programs adequately addresses these safety issues, and that fuel cell providers recognize their responsibility.

It should also be noted that when listed equipment is not available, codes and standards typically require â€œapprovalâ€ of this equipment by the AHJ. This places a significant responsibility on AHJs, who may not be familiar with the technology, lack the resources to support a thorough review, or may be unaware that their review and approval covers unlisted equipment. For all of these reasons, the panel has concluded that third-party certification for these systems in these deployments should be expeditiously sought. Additionally, the panel plans to develop guidance for projects that cannot use listed equipment.

The future will likely see hydrogen's use as an energy source impact many areas of our lives, including the vehicles we drive, how consumer goods are warehoused and brought to market, and how critical emergency and communications systems are maintained through power outages. Demonstrated safety in the production, distribution, and use of hydrogen will be critical to the successful implementation of a hydrogen infrastructure and the widespread use of hydrogen technology.

Because commercial hydrogen technologies are just now emerging, the attention paid to them is amplified due to public unfamiliarity with these systems. Loss of public confidence early in this development could significantly delay or even preclude further progress in a new technology like hydrogen. For these reasons, emphasis will be placed on educating first responders, and the Hydrogen Safety Panel will continue to identify initiatives to bring focused attention, action, and outreach to bear on key safety issues for the deployment of these systems.

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