

## **DEVELOPMENT OF CODES AND STANDARDS FOR THE SAFE USE OF HYDROGEN**

**Karen I. Miller  
Robert L. Mauro  
National Hydrogen Association  
Washington, DC 20036**

### **Abstract**

Hydrogen plays a significant role in the world's energy economy, but this role is almost exclusively as a chemical - hydrogen is rarely used as a fuel. The use of hydrogen as a fuel in the utility and transportation sectors faces hurdles that need to be overcome in order to transition to a hydrogen energy economy. In addition to a lack of infrastructure to support the widespread distribution and use of hydrogen, there exists a persistent perception that hydrogen is unsafe. Widespread hydrogen use will require that safety be intrinsic to all processes and systems. To develop a hydrogen infrastructure that has the public's confidence in its safety and convenience, an industry consensus on safety issues, the development of compatible standards and formats (e.g., the same couplings for dispensing the same form of fuel), and product certification protocols are required.

The national and international standards organizations are developing the rules under which hydrogen will be produced, transported, stored and used. This ultimately evolves to trade related issues when hydrogen is in widespread use. For that day to come hydrogen must have a set of rules for code officials and fire marshals in the 35,000 jurisdictions in the United States to refer. The hydrogen community in the U.S. must participate in these activities to assure that the standards used are safe, fair and compatible with any existing domestic standards.

The NHA is under contract with the U.S. Department of Energy, through the National Renewable Energy Laboratory, to identify and develop the standards necessary. Utilizing industry expertise and coordinating with Government and other official entities, this barrier to commercialization may be overcome, allowing siting of hydrogen components and systems on a world-wide basis.

## Introduction

The development of codes and standards for the safe use of hydrogen is an essential aspect of the DOE Hydrogen Program. The objective of this work is to continue the efforts already begun on the creation of draft international standards for safety, tanks, connectors, and refueling stations, as well as identify and begin work on additional needed standards to assure the safe use of hydrogen.

The NHA seeks to create draft standards for hydrogen systems and components, utilizing expertise from industry and university research organizations, and others. These draft standards are then submitted to a standards organization, such as the National Fire Protection Agency (NFPA) or ISO/TC-197 for additional input from a broader consensus. The NHA continues to advise on matters of hydrogen safety as these items develop for acceptance and publication. In addition, the NHA participates in safety, codes and standards working groups for items drafted elsewhere.

Since the summer of 1995 the NHA has had work groups to draft standards that standards organizations can adopt and modify. To date the NHA has done this with three standards. There are several more work groups being organized. As a part of our activities we would like to have the draft standards adopted and used as a part of DOE sponsored hydrogen field tests. Thus the proposed refueling station Las Vegas and third site for hydrogen fueled buses are initial sites to validate the draft standards.

## Discussion

While this specific work has only begun in February, 1999, it builds on work done in the past through a Cooperative Agreement between the U.S. Department of Energy Hydrogen Program and the National Hydrogen Association. This work continues to be cost-shared by member dues.

### **Past Work**

The work groups listed below were established to develop standards based on the experience of the natural gas industry and to encourage safe use of hydrogen in vehicle applications. Each work group is composed of experts from industry and research institutions.

#### ***Work Group 1: Connectors***

This group identified key differences in materials and processes to ensure that hydrogen fuel connectors are standardized to fit only hydrogen dispensing stations and tanks. In addition, key technical issues included connector requirements for gaseous versus liquid hydrogen, as well as standardization of pressures for dispensing gaseous hydrogen. The draft standard developed by this work group was accepted by International Standards Organization Technical Committee 197 (ISO/TC-197) as a work item. This is an essential step in the establishment of an international standard. The NHA continues to provide expertise to this work item.

#### ***Work Group 2: Containers***

This group called upon experts in the hydrogen and tank industries to develop a draft standard

for hydrogen storage tanks. Commercially available tanks were not designed for hydrogen storage. Hydrogen embrittlement may develop in certain metal tanks under conditions of heat and pressure. In addition, concerns regarding hydrogen storage pressures and temperatures, as well as other safety considerations were addressed. This work group addresses key technical requirements unique to tanks for hydrogen storage. This draft standard was accepted by ISO/TC-197 as a work item. The NHA continues to provide expertise to this work item.

### ***Work Group 3: Service Stations***

This group is identifying key technical differences in requirements for natural gas service stations and those planned for hydrogen. Material compatibility issues, as well as safety considerations for hydrogen's wider combustible limit are being addressed to assure that future hydrogen refueling stations meet equivalent safety criteria as natural gas refueling stations. In addition, consideration is given to satisfying requirements of local code officials, to allow the siting of hydrogen refueling stations. This item is ongoing, and is being developed nationally through the National Fire Protection Agency (NFPA), as well as internationally through ISO/TC-197. The NHA continues to provide expertise to this work item.

### ***Sourcebook for Hydrogen Applications***

The NHA participated in the development of *The Sourcebook for Hydrogen Applications*, a joint effort by Canadian and US experts to compile in an easy-to-use document the prevailing practices and applicable codes, standards, guidelines, and regulations for the safe use of hydrogen. The effort was funded jointly by Natural Resources Canada (NRC) through the Hydrogen Research Institute (HRI) at the University of Quebec and by the U.S. Department of Energy (DOE) through the National Renewable Energy Laboratory (NREL). The *Sourcebook* was prepared under the joint sponsorship of the Canadian Hydrogen Association and the National Hydrogen Association.

The purpose of the *Sourcebook* is to serve as a reference to available information that developers can use to design, build, and operate safe hydrogen projects at a non-industrial scale. The *Sourcebook* is not intended to be a design handbook. Furthermore, the *Sourcebook* will not be a substitute or an interim surrogate for codes and standards that are being developed by working groups under the International Standards Organization (ISO) and will not obviate the need for detailed safety reviews of specific projects. However, codes and standards typically take many years to write and adopt, and the *Sourcebook* will fill a need for an easy-to-use reference for both developers and local code officials while, and even after, appropriate codes and standards are adopted and incorporated into relevant fire, building, and other codes. The value of the *Sourcebook* will be that mutual concerns of code officials and project developers will be identified with examples of how such concerns have been addressed. The *Sourcebook* should help facilitate understanding about safety issues and provide a basis for code officials and developers to identify and resolve safety concerns.

The NHA continues to encourage use of the *Sourcebook*, and stands ready to assist in any future activities to enhance or update the *Sourcebook*.

## **Progress to date**

Progress during the first quarter for each task under this contract is described below:

### ***Task 1: Facilitation of the Development of Recommended Practices and Codes and Standards***

Discussions continue on the timing and location of a potential workshop. While no date has yet been set, it is anticipated that the NHA will hold a workshop in August in Washington, DC. Additional working group meetings may be held as necessary following this workshop.

### ***Task 2: Determination of the Need for the Development of Additional Recommended Practices and Codes and Standards***

At a Codes and Standards (C&S) Workshop held in July 1998, a list was generated containing additional items for consideration. From this list, the items of near-term importance for the hydrogen community must be defined and work groups established. The list of items under consideration follows:

- C&S for the use of electrolyzers and fuel cells at customer sites, including homes.
- C&S on self-service of hydrogen vehicles.
- Restrictions on servicing and storing vehicles indoors under existing C&S.
- C&S for hydrogen hookup and use for home heating and power generation.
- C&S for safe self-service refueling of vehicles with hydrogen.
- Certification program for hydrogen vehicle fuel systems.
- Development of in-place testing and certification of hydrogen tanks in vehicles.
- C&S for maritime unique applications of hydrogen (identify unique applications).
- C&S for subsonic aircraft.
- C&S for small scale transportable fuel cells as battery replacement/portable generation.

Workshop participants agreed to prepare a justification page for each proposed work item above. The NHA has reviewed and collated the responses as to work item priorities. This served as the basis for developing a list of potential work items for recommended practices and codes and standards that are critical for the commercial use of hydrogen as an energy carrier. The required deliverable for this task is being submitted concurrently with this quarterly report. There will be four new work items, with one of the items requiring presently low-level coordination with SAE. The items which received the most favorable response from members for near-term development are:

C&S for the use of electrolyzers and fuel cells at customer sites, including homes.

C&S for safe self-service refueling of vehicles with H<sub>2</sub>.

Certification program for hydrogen vehicle fuel systems. (SAE Coordination)

C&S for maritime unique applications of hydrogen (identify unique applications).

In addition, the NHA has identified additional areas in need of development in the arena of hydrogen tanks (Work Group 2), including composite tanks presently under development, as well as metal hydride storage tanks. It has been determined, based on interest from NHA

members as well as others, that these issues will be addressed within ISO-TC/197. The NHA will continue to track the progress of these efforts and provide technical expertise as necessary.

### ***Task 3: Codes and Standards Session***

The NHA was honored to organize and conduct a plenary session for the 1999 ISO/TC 197 meeting and related ISO working groups in conjunction with the 10<sup>th</sup> U.S. Annual Hydrogen Meeting, held in April. Results of these meetings will be available through ISO.

### ***Task 4: Validation of Hydrogen Codes and Standards***

The NHA solicited and collected technical reports on current and recent demonstration evaluations. These reports were presented at several sessions at the 10<sup>th</sup> Annual U.S. Hydrogen Meeting in April. They will also be published and distributed to the members and meeting registrants in the Proceedings. The NHA will use the lessons learned in these demonstration activities to refine the existing Codes and Standards activities.

In addition, NHA staff attended the DOE Fuel Cells Codes and Standards Summit on April 5 to present the NHA activities to a larger codes and standards audience. This helps ensure experts in related codes and standards activities are aware of the existing efforts in hydrogen, as well as provide the NHA with information on the other activities.

## **Conclusions**

The development of codes and standards for hydrogen systems and components is an important aspect of the DOE Hydrogen Program. The National Hydrogen Association has been a leader in this area since 1995. The NHA seeks broad consensus from industry and government, on a national as well as an international level for development of standards. The NHA has been successful in drafting standards and having them accepted by larger standards bodies, such as ISO/TC-197. There is still much work to do in this area, as well as work to allow model building code acceptance of these hydrogen systems and components, once acceptable standards are available. The NHA is committed to working with industry, the National Labs, and the Department of Energy Hydrogen Program to continue these vital efforts.

## **Future Work**

In addition to completing the efforts already begun, as described above, the NHA will perform the following tasks under this contract:

The NHA will plan, organize, and conduct a codes and standards workshop in August, 1999 and solicit participation from safety experts and standards organizations.

In order to assist the developers of hydrogen demonstrations, the NHA will collect and evaluate information on current hydrogen field test or technology validations, with an emphasis on the

safety aspects of the projects including the codes and standards that are in use. In this effort, we will make every effort to validate the codes and standards that are being developed through the NHA, ISO, and others. We will also collect and evaluate existing general boilerplate codes that may impact hydrogen applications.

### **Acknowledgments**

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