

NHA HYDROGEN SAFETY CODES AND STANDARDS ACTIVITIES

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Abstract

The NHA holds technical conferences with industry, academia, national laboratories, code officials and model building code organizations to bring experts together in a focused activity to develop and write new standards for hydrogen technologies. This includes such items as storage tanks, fueling nozzles, connectors, safety equipment, and other key components and integrated systems needed to move hydrogen into the energy sector.

The NHA supports the development of codes and standards for hydrogen in a variety of applicable organizations. This includes providing experts, technical reports, data and other information needed by the Code Officials to complete the development of these new codes.

Introduction

The NHA has been a catalyst to identify needed codes and standards for the commercialization and deployment of hydrogen energy systems since 1995. Key technical staff, Mr. Bob Mauro and Ms. Karen Miller, have facilitated workshops and working groups, as well as participating on behalf of the hydrogen industry in related standard processes where hydrogen safety expertise is warranted. This work has historically been performed through a partnership of government and industry, using NHA membership dues as cost-share for DOE Hydrogen Program funding. Over the past three years, DOE funding has been reduced, and in some critical areas, eliminated,

putting U.S. manufacturers of hydrogen energy systems and components at risk of competitive disadvantage in a global marketplace.

This paper describes the NHA's Codes and Standards (C&S) activities only. It will show that cooperation, collaboration, and outreach is vital to developing consensus documents. We now have a wealth of information on draft C&S efforts, including identification of needed expertise, which needs to be disseminated to building code officials such as National Fire Protection Association (NFPA), local fire marshals and the public.

Other activities that the NHA performs include an annual meeting and Education and Outreach (E&O) efforts. Because of reduced DOE support, the NHA currently lacks the funding to perform the level of outreach activities necessary to educate code officials on the state of hydrogen technologies, as well as the critical task of preparing the public for hydrogen energy systems.

Mr. Mauro, who has been involved in the NHA since its inception, has recently stepped down from the management of the NHA and has been appointed Technical and Policy Advisor to the NHA Board of Directors. He remains active in the ISO TC-197 portion of the NHA's codes and standards activities. His ongoing role in codes and standards for the NHA is described in this paper.

Discussion

The difference between "Codes" and "Standards" is described here, followed by a description of the role of the National Hydrogen Association in the development of both codes and standards.

Codes

Most jurisdictions have multiple requirements, such as building code, fire code, mechanical code, fuel gas code, local ordinances, and others. Some codes might restrict the use of hydrogen as a fuel through definitions of "Fuel Gas" or other code language. This could prevent the widespread use of hydrogen as a fuel. Several years ago, the NHA identified some suggested work where a cooperative effort between government and industry could pave the way for inclusion of hydrogen energy systems in these requirements. These efforts include:

- Identify key codes and standards affecting hydrogen use
- Evaluate if a change to the document is warranted
- Propose revision to key codes and standards
- Work with codes and standards organizations to implement the changes

The NHA is working with the International Codes Council (ICC) Ad Hoc Committee on Hydrogen. NFPA liaison has recently been established. By working with both organizations,

hydrogen energy systems, including refueling stations, fuel cells, reformers, electrolysers, etc., will be able to be sited, without the need for a cadre of experts to visit each local fire marshal.

Standards

Standards are created to assure consistency in safety and performance of a product or system. The NHA is involved in codes and standards because industry saw a need to assure public confidence in hydrogen energy systems and remove a barrier to commercialization, specifically a lack of consensus codes and standards. The NHA drafts standards where none exist, works with other groups on related standards to provide hydrogen safety expertise, and remains active in both National and International standards development.

Goals and Objectives – Long-Term

The NHA's long-term goals and objectives are:

- To facilitate the development of a hydrogen infrastructure that has the public's confidence in its safety and convenience
- To build an industry consensus on hydrogen safety issues
- To ensure compatibility between various applicable hydrogen codes and standards
- To provide a forum for issues, to present consensus hydrogen energy input domestically, and to furnish a collective U.S. hydrogen industry position at international forums.

Goals and Objectives - This Term

As hydrogen continues to move toward commercialization, the NHA's objective is to continue the process of developing international standards for safety, tanks, connectors, and refueling stations, and identify and begin work on additional draft standards for the safe use of hydrogen. Collaboration with other standards bodies is a key element.

NHA's technical goal is to create draft standards for hydrogen systems and components using the expertise of our membership.

Specific objectives for the current C&S effort are to advance work items that the NHA membership started in previous years. These include:

- Conduct a C&S Workshop,
- Take a leadership role in ISO-TC-197,
- Provide hydrogen expertise to IEC-TC-105 U.S. Technical Advisory Group (TAG) on Fuel Cell Technologies, the International Code Council Ad Hoc Committee on Hydrogen, and the Society of Automotive Engineers Fuel Cell Standards Safety Working Group, and

- Facilitate information exchange on hydrogen technologies and infrastructure issues to enable broad consensus building on C&S issues.

Milestones

The following milestones include those activities consistent with the Annual Operating Plan that were actually funded for this period.

Conduct C&S Workshop

The NHA C&S workshop was held on March 5, 2001 in Washington, DC. The proceedings are in preparation, and should be completed by the end of May. One of the highlights of the workshop was a lively discussion between industry, Underwriters Laboratory and the U.S. Department of Transportation on classification of metal hydrides for hydrogen storage.

Take a Leadership Role in ISO-TC-197

Mr. Mauro was elected Chairman of the U.S. TAG for ISO-TC-197. He attended applicable training sessions in February 2001. Courses were: Strengthening the U.S. Voice in International Standardization - The Operating Procedures of ANSI-Accredited TAGs to ISO, and Taking the Secret out of Secretariat: ISO Secretariat Operations. The NHA hopes to conduct regular meetings of U.S. industry prior to ISO-TC-197 plenaries to reach consensus and assure that U.S. interests are considered. A trip report on these courses was submitted to Sandia National Laboratory (SNL) in March and is available on the NHA website.

Update on ISO-TC-197, Hydrogen Technologies Work Item Progress

- WI 15916 Basic Considerations for the Safety of Hydrogen Systems: Final editorial changes have been approved for circulation of the Draft Publicly Available Specification. This document was circulated to the P-members of ISO-TC-197 through May 20, 2001.
- WI 15869 Gaseous Hydrogen and Hydrogen Blends-Land Vehicle Fuel Tanks: To be circulated as a Draft International Standard for a five-month voting period in the next month or two.
- WI 17286 Gaseous Hydrogen-Land Vehicle Filling Connectors: This work item is being advanced, addressing design issues of potential cross-connection. It is still in the working group.
- WI 15866 Gaseous Hydrogen Blends and Hydrogen Fuel-Service Stations: This item is stuck at the working group level. Issues regarding the baseline document and convenor availability are being worked out.

- SAE Documents are a Recommended Practice, but will likely become standards through ISO TC 22/SC21.
- IEC-TC-105 work items are just getting started and are described below.

The NHA developed a draft standard on hydrogen refueling stations for ISO-TC-197. The work item was accepted, but it has not advanced on schedule due to lack of U.S. support for convening this working group.

Provide Hydrogen Expertise to IEC-TC-105 U.S. TAG on Fuel Cell Technologies, the International Code Council Ad Hoc Committee on Hydrogen, and the Society of Automotive Engineers Fuel Cell Standards Safety Working Group

IEC-TC-105

Ms. Miller participated in the first full meeting of the U.S. TAG members of IEC-TC-105 on March 13, 2001, in Lake Buena Vista, Florida. Mr. Kelvin Hecht, formerly of International Fuel Cells, is Chair of the U.S. TAG. Mr. David Conover serves as Deputy Technical Advisor.

New work item proposals discussed are as follows:

- #105/10/NP: Terminology – Fuel Cell Technologies - Project Leader: Mr. Kelvin Hecht, USA - This proposed work item takes the Fuel Cell Glossary developed by the U.S. Fuel Cell Council, adds the Japanese Standards Association Glossary of Terms for Fuel Cell Power Plants, TR C 0001, and builds an international terminology document for future IEC-TC-105 work items.
- #105/11/NP: Fuel Cell Modules - Project Leader: Dr. Gerhard Filip, Germany - The scope of this document is Safety, EMC, quality assurance and environmental aspects of fuel cell modules in all applications.
- #105/9/NP: Stationary Fuel Cell Power Plants – Safety - Project Leader: Mr. Kelvin Hecht, USA - The scope of this proposed work item is performance-based requirements for the design, construction, testing and making of packaged fuel cell power plants. The purpose is to harmonize requirements from EU, Japan and USA using European Directives, MITI requirements and ANSI Z21.83.
- #105/6/NP: Fuel Cell: Testing Methods for Performance of Fuel Cell Power Facility - Project Leader: Mr. Tosiro Terayama, Japan - This standard is intended to cover the test methods for 1) Raw fuel consumption, 2) Temperature and quantity of heat recovered from fuel cell power facilities, 3) Electrical efficiency, 4) Overall thermal energy efficiency, 5) Load following and output power change, 6) Start-up time and shut-down time, 7) Cell stack voltage and current, and 8) Reactive power. The group noted that this scope is significantly beyond the scope of known U.S. standards. U.S. fuel cell manufacturers are encouraged to participate in the development of this standard.

A new work item proposal, not yet numbered, will be submitted to IEC-TC-105 to address Stationary Fuel Cell Power Plants – Installation. The proposed project leader will be Andrew Skok, USA. The group was given the opportunity to sign on to participate in this work item as U.S. experts. Ms. Miller signed on from the perspective of coordination between this activity and the work of the ICC Ad Hoc Hydrogen Committee, which is proposing changes to the U.S. model building codes for installation of fuel cells.

Other new work items are anticipated, but no formal request is yet available. NHA staff indicated a willingness to participate on any item that required a hydrogen-safety review or coordination with other U.S. activities where the NHA is participating.

ICC Ad Hoc Hydrogen Committee

A meeting of the International Code Council Ad Hoc Committee (AHC) on Hydrogen was held in conjunction with the 2001 ICC Code Development Public Hearings March 17-31, 2001, in Portland, Oregon. The ICC hosted this meeting Tuesday, March 20 through Thursday March 22, 2001 at the DoubleTree Hotel-Jantzen Beach.

Ms. Miller attended on behalf of the NHA. Her trip report was provided to SNL, DOE, and National Renewable Energy Laboratory following the meeting. In order to keep the hydrogen community informed, Ms. Miller posts trip reports and any draft codes and standards on the NHA *Members' Only* website. In addition, she publishes the information in an informational article in the NHA's quarterly publication, the *NHA News*.

Guy Tomberlin, AHC Chair, explained that the requested changes to the International Mechanical Code and the International Fuel Gas Code constituted the definitions of stationary fuel cell power system and portable fuel cell power system developed through the AHC meetings. One of the AHC's requested changes to the International Mechanical Code would be heard right away, and experts on hydrogen, as well as anyone who could offer supporting statements for the proposed changes should be prepared to speak.

The AHC's change was first on the agenda. Mr. Tomberlin read a statement of support. There was no opponent to the change. A motion to accept the change as submitted was offered and seconded. The motion passed unanimously.

The AHC's second proposed change to the International Mechanical followed the same format, with no opposition, and passed unanimously. The next step is a public comment period, and a final membership approval in September.

Similar code changes to the International Fuel Gas Code were presented, and Mr. Tomberlin was again the proponent. One of the Committee members questioned a change to the code that said it was important to define Portable Fuel Cell Power Systems, so that it was clear what was portable and what was stationary, as the code did apply to stationary. A motion was made to reject the change. After discussion, the motion to reject the change passed 7-5. The voting members then discussed and voted to file an action in support of the change. This vote passed 86-15.

The final AHC change was presented a short time later. After discussion, it passed.

The next day began with a discussion of progress from working group 3 (WG3) on hydrogen vehicle fuel-dispensing stations. Significant progress was made in identifying references in the codes to allow hydrogen. The work item presently includes gaseous hydrogen only. It was determined that the group would focus on this initially so that the group does not get bogged down in too many details. The group recognized the need to address vehicle service stations, and agreed to do so in the fire code, but not as part of this WG3 effort. It was recommended that the WG3 complete the effort, and make appropriate provisions for hydrogen blends and liquid hydrogen, if necessary.

Society for Automotive Engineers

The Society for Automotive Engineers (SAE) is seeking closer liaison with the NHA in the development of codes and standards of mutual interest. The NHA plans to attend two meetings of this group under this contract. The group meets monthly in Michigan. Ms. Miller attended a meeting in April and plans to attend one in June of this year under the current funding. The NHA does not anticipate attending each monthly meeting, but attendance quarterly is justified.

The Mission Statement of the SAE Fuel Cell Standards Committee is as follows: "Establish standards for vehicle fuel cell systems and its interfaces to the vehicle."

Scope. "The standards will cover the safety aspects of fuel cell systems in vehicles, test procedures to establish the performance of the system/components, and interface requirements."

Efforts Underway:

- Safety Working Group, Recycling Working Group
- Interface Working Group
- Performance Working Group
- Emissions & Fuel Economy
- Terminology
- Reliability

The NHA has taken a role on the Safety and Interface working groups. In many cases, there is no substitute for actually being there to speak on behalf the hydrogen industry. At the April meeting, the convenor of the Safety Working Group was seeking volunteers to address certain elements of the draft standard. The group was determined to use the expertise they had, but if none was available, that element might be excluded from the document. Ms. Miller volunteered to find an expert so that hydrides could be included.

Facilitate Information Exchange on Hydrogen Technologies and Infrastructure Issues to Enable Broad Consensus Building on C&S Issues

Leadership

The NHA's leadership in cooperation with key stakeholders is really what this effort of consensus codes and standards is all about. The NHA participates actively in the development of codes and standards on a national and international basis. The NHA creates draft standards only when our members express a need for the standard in the next 3-5 years, and there are no ongoing efforts to develop the standard. The NHA does not publish standards, so it is imperative that we work with organizations that do. Key staff are active members of the SAE Fuel Cell Standards Committee, the International Codes Council (ICC) Ad Hoc Committee on Hydrogen, and a number of international efforts, including IEC-TC-105 and ISO-TC-197. The NHA presents status of C&S activities at applicable technical conferences and forums, including the DOE Fuel Cell Codes and Standards Summit, NHA C&S Workshops, and other conferences when funding permits. Currently the NHA is participating in an on-line conference for EnergyResource2001 by presenting the NHA's role in C&S activities. Last year the NHA presented these activities at an IQPC conference on Fuel Cell Infrastructure.

The NHA keeps its members informed of progress in the development of hydrogen safety, codes and standards through publication in its quarterly newsletter and by posting information, including draft standards, on the NHA *Members' Only* website. This allows NHA members an opportunity to review the work of other organizations that have requested collaboration with the hydrogen community. The general articles published in the newsletter are made available to the public on the NHA website, and mailed to NHA members. In this way, the information is distributed broadly, and interested parties are given an opportunity to get involved in the standards development process.

The NHA Board is working to develop opportunities to keep up this important work in light of the DOE funding difficulties. It is imperative that additional resources are developed to disseminate the information we are gathering on the draft codes and standards that are being developed, and the issues that impact U.S. manufacturers. In addition, the public must be educated on the benefits and safety of hydrogen energy systems.

Status of Progress - National

NHA Work Items:

- WG1: Connectors
- WG2: Containers
- WG3: Refueling Stations
- WG4: Use of electrolyzers and fuel cells at customer sites, including homes.
- WG5: Safe self-service refueling of vehicles with H₂ (SAE Interface & Safety working groups)
- WG6: Certification program for hydrogen vehicle fuel systems (SAE Coordination)
- WG7: C&S for maritime unique applications of hydrogen (identify unique applications).

The NHA currently supports seven Codes and Standards Working Groups. Connectors and Containers work may continue for higher pressures, if interest and funding allow. Currently the Containers working group is focused on working with the U.S. Department of Transportation on hydride transport.

WG 4-7 began in August 1999. Since that time, funding for the NHA C&S efforts has been intermittent at best. This has impacted the ability to get the work groups together, and conduct outreach with outside experts, in order to advance these items.

There has been some progress, however, particularly on hydrides and maritime. These efforts will be described in the C&S Workshop Proceedings from the March 5 meeting.

The scope of WG 4 is to develop a standard for installation, safety and use of electrolyzer hydrogen generators in end use applications, including the residential, commercial and industrial sectors. Activities will include identifying appropriate group participants in addition to NHA members, assessing the existing relevant codes, establishing parameters and developing a technical envelope for the WG. A code/building and zoning review will also be important to this WG. Finally, the NHA would like to develop a draft standard based on an appropriate template document and scope.

WG 5 will specify design criteria for safe self-service refueling with liquid and gaseous hydrogen. This will include consideration for vehicle grounding, venting of fuel lines and elimination of possible ignition sources. This activity is in conjunction with the SAE Interface and Safety working groups.

The scope of WG 6 is to verify the performance of on-board hydrogen systems. These systems must be safe and perform to specified vehicle standards. The hydrogen system includes storage, generation, distribution, power source, and controls. The NHA is actively working with SAE Fuel Cell Standards Forum C&S safety task force and disseminates the information to WG 6 members.

The scope of WG 7 is to identify maritime-unique applications of hydrogen. This was done in cooperation with the Maritime Hydrogen Technology Development Group as well as other interested standards bodies. The MHTDG has published a massive report on the subject, and provided the NHA with two copies. The group has indicated an interest in taking the maritime work farther, if funding permits.

The NHA is currently working with the ICC to provide technical input and industry support for changes to the model building codes to allow certain hydrogen fuel appliances to be sited. The NFPA has recently developed an interest in hydrogen, and would like to work with the NHA to provide the hydrogen expertise to their working group, which will be similar to the ICC work. The NHA presently is not funded to participate in these activities, but can do it if we are awarded the 3-year contract for C&S activities from DOE. A 3-year contract will significantly improve our ability to plan and conduct workshops, and keep stakeholders, including code officials and the public, informed of the progress.

Status of Progress – International

The NHA has a formal liaison relationship with ISO-TC-197. Mr. Mauro serves as the Chair of the U.S. Technical Advisory Group for 197. His duties include:

- Work with the U.S. TAG Administrator to coordinate U.S. TAG positions
- Coordinate meetings
- Take a lead role in bringing U.S. interests to ISO
- Lead in identifying potential members of the U.S. TAG

Ms. Miller serves on the permanent editing committee, to review draft documents before circulation to ensure that they are in proper English, and do not contain gaps in definitions or data.

Ms. Miller is also a member of IEC-TC-105 and strives to assure the group has liaison with ISO.

IEC-TC-105, when formed, was made up of only fuel cell manufacturers. Participation of other entities, such as NHA and SAE, helps provide the necessary diversity to create a consensus standard.

Although the NHA does not participate on ISO-TC-22/SC 21 work items, automotive members are involved, and the broader NHA involvement occurs in two places - first the SAE work feeds into TC-22/SC 21. Secondly, TC-22/SC 21 has recently agreed to a liaison with ISO-TC-197 on hydrogen issues.

The NHA has been very effective at bringing forward concerns from U.S. members, including the National Labs. We've been able to effect favorable changes in standards brought forward from other countries.

An association, such as the NHA, is able to garner a great deal of consensus. The NHA is especially well-positioned to do this because of the diversity of membership. We are developing standards with input from energy companies, industrial gas suppliers, fuel cell manufacturers, safety equipment and service suppliers, and others.

Proposed Future Work & Milestones

The ICC AHC initial activities are expected to be completed in the 2-3 year timeframe. Building codes are always being revised, and as more hydrogen energy systems become commercial-ready, there is bound to be additional activity required. We do, however, anticipate that the heaviest activity is the current effort, where we are educating building code officials who

recommend changes to the model building codes. NHA support is likely to diminish to special technical or industry support in the outyears.

Very recently, the NFPA has asked for NHA assistance in the development of hydrogen refueling station activities. Some jurisdictions may rely on ICC codes while others rely on NFPA. The NHA will work to ensure these codes are consistent and meet the needs of the industry. In addition, we will strive to broaden the scope beyond refueling stations.

We hope to be able to continue to provide expertise on hydrogen to other C&S efforts, like the SAE, DOE FC C&S Summit, and others, as well as continue providing this support to ISO and IEC. We hope to prepare additional work item proposals on the ongoing work items described earlier, and others that may be needed in the near future, such as 10,000 psi gaseous hydrogen systems, particularly composite storage tanks.

The European Union has adopted a series of hydrogen standards, and is seeking to harmonize those with North America. It will be necessary to work with many manufacturers and organizations to assure that U.S. interests are not overlooked. While European and Canadian companies are receiving significant funding from their governments to develop international standards based on national interests, this is not the case in the United States. The NHA must bridge this gap by assuring that these standards consider U.S. interests. This involves identifying issues and convincing the stakeholders to spend some time looking at the draft standards, and where necessary, participate in the process. Few U.S. hydrogen industry businesses can afford to follow all the activities, let alone participate in them. If someone isn't looking out for them, the international standards that are developed may be unfavorable for U.S. industry.

Conclusions

The National Hydrogen Association has members from automobile companies, fuel cell developers, gas producers, chemical companies, and others. The NHA serves as a catalyst for information exchange and cooperative projects and provides the setting for mutual support among industry, government, and research/academic organizations and provides a national focal point for hydrogen interest and information transfer.

The development of codes and standards allows hydrogen energy systems to be produced, sold, and sited commercially, while increasing public confidence in safety and reliability. U.S. leadership and participation ensures a level playing field that allows equitable distribution of U.S. products globally. Standards could become non-tariff trade barriers. Rules for international trade in hydrogen and hydrogen-related products are being written now. Other industrialized countries have taken initiatives to present their views of the development of rules for hydrogen and hydrogen-related products.

The main barriers to wide-scale use of hydrogen-fueled cars and fleets include lack of infrastructure, public acceptance, coordination and collaboration among potential fleet operators, and applicable codes, standards, and other safety information that can enable siting and ensue the required infrastructure. Removal of these barriers requires that government organizations work

together, and include industry and academia where appropriate to educate the public and prove that fleets of hydrogen-powered vehicles can be operated safely and cost-competitively. The NHA allows a forum for these issues to be discussed and resolved.

European countries, and even Canada, fund their industries to participate actively in the development of C&S that favor their national interest. The U.S. is not doing this and this could result in C&S that favor these countries, to the detriment of U.S. manufacturers. The NHA can bridge this gap by building consensus, looking out for issues that may be unfavorable to U.S. interests, and alert U.S. manufacturers of activities and issues that should be looked at by these companies. The NHA is interested in doing more of this necessary coordination work, particularly now that the European Union is seeking to harmonize their standards with North America.

Acknowledgments

U.S. Department of Energy provided cost-shared funding through Sandia National Laboratory for this effort.

Mr. Mauro and his longstanding efforts in the identification and development of needed codes and standards for hydrogen energy systems, and leadership in establishing an effective NHA C&S program.