A NATIONAL SET OF HYDROGEN CODES AND STANDARDS FOR THE US

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ABSTRACT

In 2003 the US Department of Energy (DOE) initiated a project to coordinate the development of a national template of hydrogen codes and standards for both vehicular and stationary applications. The process consisted of an initial evaluation to determine where there were gaps in the existing hydrogen codes and standards and the codes and standards required to fill these gaps. These codes and standards were to be developed by several Standards Development Organizations (SDOs). This effort to develop codes and standards has progressed from a position in 2003 when there were relatively few codes and standards that directly addressed hydrogen technology applications to the position at the end of 2008 where requirements to permit hydrogen technologies have been implemented in primary adopted codes- building and fire codes, in hydrogen specific codes such as National Fire Protection Association (NFPA) 52, NFPA 55, and NFPA 853, and in many of the hydrogen specific component standards that are referenced primarily in the NFPA codes and standards. This paper describes the three levels of codes and standards that address hydrogen technologies for the built environment:

Level 1. Primary adopted building and fire codes

Level 2. Hydrogen specific codes and standards references in primary adopted code

Level 3. Hydrogen specific component standards referenced in hydrogen specific codes

This paper also describes the progress to date in populating these three levels with the required hydrogen codes and standards. The first two levels are essentially complete and are undergoing refinement and routine revision. Level 3, the hydrogen specific component standards, is the furthest from having first edition documents that address requirements for a hydrogen system component.

The DOE is focusing much of their codes and standards development efforts on these hydrogen specific component standards with the expectation that a first edition of most of these standards will be issued by 2010.

1.0 Introduction

In 2003 the DOE developed a National Template of hydrogen codes and standards to address hydrogen technology infrastructure requirements. The template listed systems and components and identified Standards Development Organizations (SDOs) that would develop requirements for the different systems and components. Significant progress has been towards completing the codes and standards that address the various systems and components. However, this template was not organized to reflect the regulatory structure that most jurisdictions use in codes and standard adoption and application. This paper will present the hydrogen codes and standards organized in structure that enforcing jurisdictions would typically apply. This structure translates into a national set of hydrogen codes and standards.

2.0 MAIN BODY

The structure of hydrogen codes and standards for the built environment, moving from codes directly adopted by jurisdictions to referenced component standards, is a pyramid. Figure 1 Hydrogen Code Hierarchy shows the codes and standards pyramid, the progression from

Level 1 primary adopted codes to;

Level 2 hydrogen specific codes and standards referenced in primary adopted codes to;

Level 3 component standards referenced in hydrogen specific codes and standards.

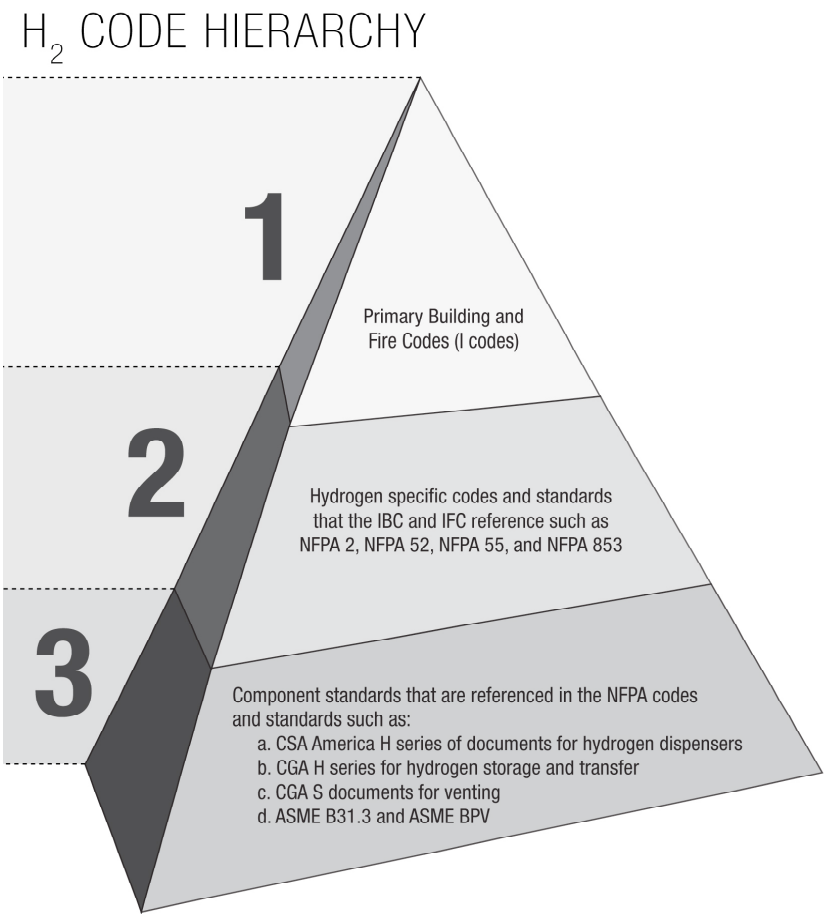

Figure 1. Hydrogen Codes and Standards Hierarchy

The hierarchy of codes and standards starts with level 1, codes that are directly adopted by a jurisdiction. A jurisdiction is an organization that has legal authority to enforce laws over defined geographic areas or facilities. A city government has jurisdiction over a city while the US Defence Logistics Agency (DLA) has jurisdiction over US Department of Defense (DoD) facilities that are located in several different geographical areas. Most jurisdictions adopt a building or building and fire code. This adoption may take the form of referencing a fire or building code in administrative regulations or placing the entire building or fire code in the jurisdiction's regulations as modified to reflect concerns specific to the jurisdiction.

Table 1 lists key hydrogen technology codes and standards by the Standards Development Organization (SDO) responsible for the document. This table gives the status as of March 2009. This document is meant to give an overview of the development of hydrogen codes and standards and an assessment and basis for the progress to date.

Table 2 lists three classes of documents to give a qualitative estimate of the extent that the National Template of hydrogen safety codes and standards has been completed. This estimate is produced with the fundamental assumption that codes and standards are constantly being revised. Part of the requirements of being an American National Standards Institute (ANSI) accredited SDO is that all documents must be placed on at least a five-year revision cycle. This requirement ensures that documents are revised to reflect changes in technology and increased safety knowledge such as lessons learned from incidents. Therefore, for this analysis percent completion is defined as the work required to produce a first edition of a document that addresses a particular topic.

The three classes in Table 2 are as follows:

Primary Adopted Building and Fire Codes

Hydrogen Technology Codes and Standards

Component Standards and Fuel Standards

2.1 Primary Adopted Building and Fire Codes

Around 2001, DOE began working with The International Code Council (ICC) to introduce hydrogen specific requirements into the building and fire codes. Most states adopt an edition, not necessarily the current edition of the ICC building and fire codes. The DOE effort was successful and hydrogen requirements were incorporated into the 2003 editions of the ICC building, fire, fuel gas and mechanical codes. Approximately 80% of the hydrogen specific requirements in the ICC codes reside in the International Fire Code (IFC). These requirements were further refined in the 2006 editions of these ICC codes. As a point of clarification, although approximately one third of the states use NFPA 1 Uniform Fire Code, the ICC building code requires compliance with the IFC. Therefore, effectively all states use the IFC.

These building and fire codes are called primary adopted codes because states and other jurisdictions directly adopt these documents through administrative law procedures to make them regulations in the jurisdiction. Building and fire codes must dictate broad safety requirements because they cover so many different applications. Because first editions of building and fire codes that contain broad hydrogen specific requirements have been completed, this first level is at the 100% completion level.

2.2 Hydrogen Technology Codes and Standards

This second level of documents is codes and standards that have specific detailed requirements that address hydrogen technologies. These documents are referenced in building and fire codes and become enforceable documents through these references. Examples of these documents are NFPA Vehicle Fueling Code 2006 edition that has lengthy requirements for fueling hydrogen-powered vehicles. The bulk of the documents at this level are NFPA codes and standards. There is a major DOE supported project to take all the NFPA hydrogen related documents and portions of documents and integrate them into a single document, NFPA 2 Hydrogen Technologies Code. NFPA 2 will also address gaps in the NFPA requirements for hydrogen, such as hydrogen producing devices. This document is scheduled to be produced on the Fall 2010 NFPA revision cycle. A draft of NFPA 2 will be available for submission of public proposals by March 11, 2009. Because of this major project, the level for Hydrogen Codes and Standards is deemed to be 80% complete.

2.3 Component Standards and Fuel Quality Standards

This third level of documents that set very detailed requirements for system component or subsystems such as venting systems. These documents are references by the level 2 documents and become enforceable documents through these references. There is most work to be done at this level to meet the objective of having a first edition of document that addresses a specific component or subsystem. There are several areas where there is significant activity:

The developments by CSA America of a series of documents that address hydrogen dispensing equipment. There will be standards for system components such as hoses, nozzles, and dispensers.

The development of a hydrogen fuel quality standard for PEM fuel cells – these requirements will appear in both a Society of Automotive Engineers (SAE) document and International Organization for Standardization (ISO) document.

The development of American Society for Testing Materials (ASTM) standards that will define how the contaminants specified in the SAE and ISO document will be tested

The development of SAE fuel system standards

DOE is providing significant support for these projects. This support is being provided in a variety of ways such as funding individuals to join technical committees and work on document development, providing test data to support document development, and coordinating meetings to keep documents on their production schedule.

There are several component standards that are complete including an entire series of hydrogen specific standards produced by the Compressed Gas Association (CGA).

Table 1. Status of National Templates Codes and Standards

Standard, Model Code	Organization	Status
Hydrogen Fueled Vehicles		
J2572 Recommended Practice for Measuring Fuel Consumption and Range of	SAE[1]	Issued October 27, 2008

Fuel Cell and Hybrid Fuel Cell Vehicles Fuelled by Compressed Gaseous Hydrogen		
J2574 Fuel Cell Vehicle Terminology	SAE	Issued March 13, 2002
J2578 Recommended Practice for General Fuel Cell Vehicle Safety	SAE	Issued January 12, 2009
J2579Technical Information Report for Fuel Systems in Fuel Cell and Other Hydrogen Vehicles	SAE	Issued January 6, 2009
J2594 Recommended Practice to Design for Recycling Proton Exchange Membrane (PEM) Fuel Cell Systems	SAE	Issued September 2, 2003
J2600 Compressed Hydrogen Surface Vehicle Refueling Connection Devices	SAE	Issued October 4, 2004
J2615 Testing Performance of Fuel Cell Systems for Automotive Applications	SAE	Issued January 5, 2005
J2616 Testing Performance of the Fuel Processor Subsystem of An Automotive Fuel Cell System	SAE	Issued June 29, 2005
J2617 Recommended Practice for Testing Performance of PEM Fuel Cell Stack Sub-system for Automotive Applications	SAE	Issued November 5, 2007
J2719 Information Report on the Development of a Hydrogen Quality Guideline for Fuel Cell Vehicles	SAE	April 18, 2008
J2799 70 MPa Compressed Hydrogen Surface Vehicle Fuelling Connection Device and Optional Vehicle to Station Communications	SAE	May 24, 2007
Pressure Relief Devices	CSA[2] (HPRD1)	Draft design-based standard being transformed to performance-based
Hydrogen Gas Vehicle Fuel Containers	CSA HGV2	Work in progress
Infrastructure		
Hydrogen tanks	American Society of Mechanical Engineers	B&PVC Project Team developing new rules for incorporation into B&PV

	(ASME)[3]	Code
Pipelines		
Hydrogen piping and pipelines	ASME	B31.12 project team developing a new code
Dispensing Systems		
Dispensing systems	CSA (HGV 4.1)	Draft Standard issued April 2009
Hoses	CSA (HGV 4.2)	Draft Standard issued April 2009
Temperature compensation devises	CSA (HGV 4.3)	Being reviewed- should be Issued in mid-2009
Breakaway devices	CSA (HGV 4.4)	Draft Standard issued April 2009
Priority/sequencing	CSA (HGV 4.5)	Draft Standard issued April 2009
Manually operated valves	CSA (HGV 4.6)	Draft Standard issued April 2009
Automatic high pressure valves	CSA (HGV 4.7)	Draft Standard issued April 2009
Fueling station compressors	CSA (HGV 4.8)	Being reviewed by compressor mfg.- should be Issued in mid-2009
Hydrogen fueling system	CSA (HGV4.9)	Draft Standard issued April 2009
Hydrogen Fittings	CSA (HGV 4.10)	
Interface		
Fuel specification for PEMFC vehicles	ISO[4] TC197	Technical Specification ISO 14687-2
Fuel specification for PEMFC vehicles	SAE	Technical Information Report published, but being revised
Weights and Measures	National Institute of Standards (NIST)[5]	Draft standard developed

Fuel Quality Assurance (test protocols to show that the requirements of ISO/SAE fuel quality standards are met)	ASTM[6]	Draft standards being developed
Built Environment Hydrogen Model Codes		
Fueling station requirements	ICC[7]	06/07 revision cycle completed
Hydrogen production rooms	ICC	06/07 revision cycle completed
Vehicular fuel systems	NFPA[8] 52	2006 Edition published, 2008 revision cycle in progress
Gaseous, liquid fuel storage/handling	NFPA 55	2005 Edition published, 2010 document to be issued August 2009
Hydrogen for all applications	NFPA 2	Consensus code for all applications in single document scheduled to be issued January 2011
Building construction/safety code	NFPA 5000	This document is not used by most jurisdictions
Stationary, Portable Fuel Cells		
Fuel cells for telecommunications	Underwriters Laboratories (UL)[9] 2266	Draft Standard development in progress
Pressure vessels for portable metal hydride systems	CGA[10] C-21 (Design, Qualification, and Testing for Pressure vessels for Portable Metal Hydride Systems)	New standard developed in 2007
Hand-transportable fuel cells	UL 2265	Draft Standard development in progress
Hand-transportable fuel cells	UL2265A	Draft Standard development in progress
Hand-transportable fuel cells	UL2265C	Draft
Gaseous hydrogen generators	UL 2262A	Final document

Gaseous hydrogen generators	UL 2264B	UL2264B completed but will be published as an Outline of Investigation
Gaseous hydrogen generators	UL 2264C	Draft standard development in progress
Other		
Industrial Electric Trucks	UL 2267	Standard completed and published

Table 2. Status of National Template for Hydrogen Codes and Standards for the Built Environment Presented in Hierarchical Structure

Document Category	Key Documents	Category Status
Primary adopted Building and Fire Codes	International Building Code 2006 edition – code that will be typically adopted through law by a jurisdiction with or without modification. The building code will contain references to comply with the: International Fire Code 2006 edition, The International Mechanical Code 2006 edition, and the International Fuel Gas Code 2006 edition. The bulk of the hydrogen requirements in the International Codes are found in the International Fire Code. These International codes contain the fundamental provisions required to install hydrogen infrastructure.	This category is considered complete because, although these International codes will go through regularly scheduled revisions, they contain the provisions required to install hydrogen infrastructure projects. These codes will typically not contain detailed technology specific requirements but instead lay a broad safety foundation that allows for more technology specific codes and standards to complete.
Hydrogen Technology Codes and Standards	The International Fire Code sections that address hydrogen and fuel cells address key NFPA documents that contain detailed	There have been major DOE supported achievements in these hydrogen and fuel cell specific codes and standards. These

	hydrogen safety requirements. Therefore, when a jurisdiction adopts the International Fire Code they will also adopt by reference the following key NFPA hydrogen related documents. NFPA 52 Vehicular Gaseous Fuel Systems Code 2009 edition and NFPA 55 Compressed gas and Cryogenic Fluids Code 2009 edition (note the International Fire Code references the 2005 edition of NFPA 55 and the 2006 edition of NFPA 52 but those references will be updated). The International Fuel Gas Code references NFPA 853 Standard for the Installation of Stationary Fuel Cell Power Plants 2004 edition. Note that NFPA 2 Hydrogen Technologies Code will extract material from NFPA 52, NFPA 55, and NFPA 853 (among many documents) to created a comprehensive hydrogen safety code. This document will likely be complete in 2010	achievements include the introduction of risk informed reproducible requirements in NFPA 55 for bulk gaseous hydrogen storage. Many quantitative code requirements have no documented technical substantiation. The introduction of these requirements into the NFPA 55 represent a major step forward in developing scientifically based code requirements and in implementing scientific research into safety codes. The incomplete work in this category is work that needs to be done to develop scientifically based requirements for liquefied hydrogen storage- as was done for gaseous hydrogen storage and to consolidate these requirements into a more easily used format- NFPA 2, the comprehensive hydrogen safety code.
Component Standards	These documents include: The H series of documents being developed by CGA America that address hydrogen dispensing operations The H series of documents developed by CGA that address hydrogen use and storage The CGA P series of documents for hydrogen vent systems The UL documents for portable hydrogen devices	There is the most new document development taking place at this level. The CGA America H series of documents that address hydrogen dispensers will be issued as final documents in 2010. The ISO 14687 fuel quality standard will likely be issued in the 2010/2011 timeframe. The SAE is also developing several documents that will be issued in the 2010/2011 timeframe.

3.0 CONCLUSIONS

The documents listed in Table 1 compromise a national set of hydrogen codes and standards for the US. For all hydrogen applications at least a first edition document has been produced to allow for the implementation of the technology. Component standards are being developed so that components are addressed in detail rather than through generic compliance processes such as case-by-case approval by the Authority Having Jurisdiction (AHJ) or third party listing. Figure 1 presents a hierarchal picture of the hydrogen codes and standards for the built environment. These documents make up the bulk of table 1.

It is expected that by 2011 almost all component and fuel quality codes and standards will be complete and that codes and standards development activity will be focused on further refining requirements and addressing developing technologies.

REFERENCES

1. SAE Publications. Society of Automotive Engineers, 400 Commonwealth Drive, Warrendale, PA 15096.
2. CSA America Publications. CSA America, 8510 Pleasant Valley Road, Cleveland, OH 44131-5575.
3. ASME Publications. American Society of Mechanical Engineers, Three Park Avenue, New York, NY 10016-5990.
4. ISO Publications. International Organization for Standardization. 1, ch. de la Voie-Creuse, Case postale 56 CH-1211 Geneva 20, Switzerland.
5. NIST Publications. National Institute of Standards, 100 Bureau Drive, Stop 1070, Gaithersburg, MD 20899-1070
6. ASTM Publications. American Society for Testing and Materials, 100 Barr Harbor Drive, West Conshocken, PA 19428-2959.
7. ICC Publications. International Code Council, 500 New Jersey Avenue, NW, 6th Floor, Washington, DC 20001-2070.
8. NFPA Publications. National Fire Protection Association 1 Batterymarch Park, Quincy, MA 02169.
9. UL Publications. Underwriters Laboratories 1 Pfingston Road Northbrook, IL
10. CGA Publications. Compressed Gas Association, 4221 Walney Road, 5th Floor, Chantilly, VA 20151-2923.