Technical Report

To:

Hydrogen & Fuel Cell Codes & Standards Reference Guide for Connecticut

By:

222 Pitkin Street, Suite 102
East Hartford, CT. 06108-3220

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Table of Contents

Subject	Page
1. Summary	
Introduction	3
Scope of Applications Addressed	3
Distributed Generation	3
Hydrogen Refueling Stations	4
Enforceable Codes & Standards for Hydrogen In Connecticut	5
2.. Evolution Of Codes & Standards for Hydrogen	
Overview	6
Regulations, Codes, Standards, and For Information Only	7
Future Expanison of Codes & Standards For Fuel Cells	7
Equipment Suppliers' Position	10
Hydrogen Refueling Stations	12
3. Appendix A Description of Codes & Standards	
References for Stationary Fuel Cell Applications	15
Additional References for Hydrogen Refueling Stations	25
4. Appendix B-	
Acknowledgements	28
References	28
Additional References	28
Lexicon for Codes & Standards Organizations	28

Codes & Standards Reference Guide

Summary

Introduction
"Codes and Standards" are fundamentally the means to ensure equipment and processes are properly designed and operated to assure the public's safety. Just as the newer technologies associated with hydrogen are evolving, so are the codes and standards. The very difficult challenge is keeping codes and standards up to date and in synchronization with progress in deploying new hydrogen technology.

Complicating matters is that there are many State, Federal, International, industry associations, and private companies working on developing cohesive and consistent codes & standards for Hydrogen and related technologies. This is an enormous task since there are at least forty-six (46) separate codes & standards from eight (8) or more standards associations. The U.S. Department of Energy maintains a website (http://www.fuelcellstandards.com/) which provides the current status of these codes & standards and is searchable by application.

This Reference Guide is a tool to help the local Authority Having Jurisdiction (AHJ) navigate through the permitting process. This Codes & Standards Reference Guide for Connecticut concerns itself with two different hydrogen applications; stationary fuel cells, which are used primarily for distributed generation, and hydrogen refueling stations. The Reference Guide assumes that the AHJ has a fundamental understanding of most of the Codes & Standards identified.

Scope of Applications Addressed by the Reference Guide
The purpose of the following is to very briefly describe the equipment and technology for the two applications addressed by this Reference Guide.

Distributed Generation (DG)
With the advent of competitive power in 1998, innovative approaches for the generation and delivery of electric power arose. The term "Distributed Power" generally describes a small power source located close to or at the site of the end user. These projects are typically less than 25 MW in capacity. Increasingly, fuel cells are being used to generate both electricity and waste heat.

Generically a fuel cell operating on a hydrocarbon fuel, consists of three functions

1. A Fuel Processor – typically either converts a gaseous fuel such as natural gas or methane from waste processing into hydrogen through a reforming process.
2. The Energy Conversion Device – is referred to as a "fuel cell" which is a device that uses hydrogen and oxygen to create electricity by a simple electrochemical reaction. A single fuel cell consists of an electrolyte sandwiched between two thin electrodes (a porous anode and cathode).

While there are different fuel cell types, all work on the same principle. According to Fuel Cells 2000 (http://www.fuelcells.org/basics/how.html) hydrogen is fed into the "anode" of the fuel cell. Oxygen (or air) enters the fuel cell through the cathode. A catalyst causes a reaction in which the hydrogen atom splits into a proton and an electron, which take different paths to the cathode. The proton passes through the electrolyte. The electrons create a separate current that can be utilized before they return to the cathode, to be reunited with the hydrogen and oxygen in a molecule of water. Individual fuel cells can then be combined into a fuel cell "stack." A typical fuel cell stack may consist of hundreds of fuel cells

3. An Inverter – an electronic device that converts DC power into AC power. (For the purposes of this Reference Guide, the inverter is excluded from this analysis because it is a common and acceptable component that has numerous established uses.)

For further description of fuel cell designs, please see www.usfcc.com.

Picture of a UTC 200 Kw fuel cell

As of December 31, 2005, the State of Connecticut uses the 2003 Edition of the ICC as its Codes for fuel cells installations.

Hydrogen Refueling Stations

There are some basic components for refueling stations but also some variations. As of January 2008, there are reportedly 165[1] refueling stations in operation and another 62[1] in the identified planning stage and/or design in the world at this time, the designs have not been totally standardized. In general, the three major components of a refueling station include:

Note 1 Available for downloading at http://www.fuelcells.org/info/charts/h2fuelingstations.pdf
Created by fuelcells2000

1. The Dispenser – the equipment that physically fills the on-vehicle hydrogen storage tank
2. The Compressor – equipment that increases the pressure of the hydrogen to the desired pressure for the vehicle. This pressure is dictated by the vehicle manufacturer.

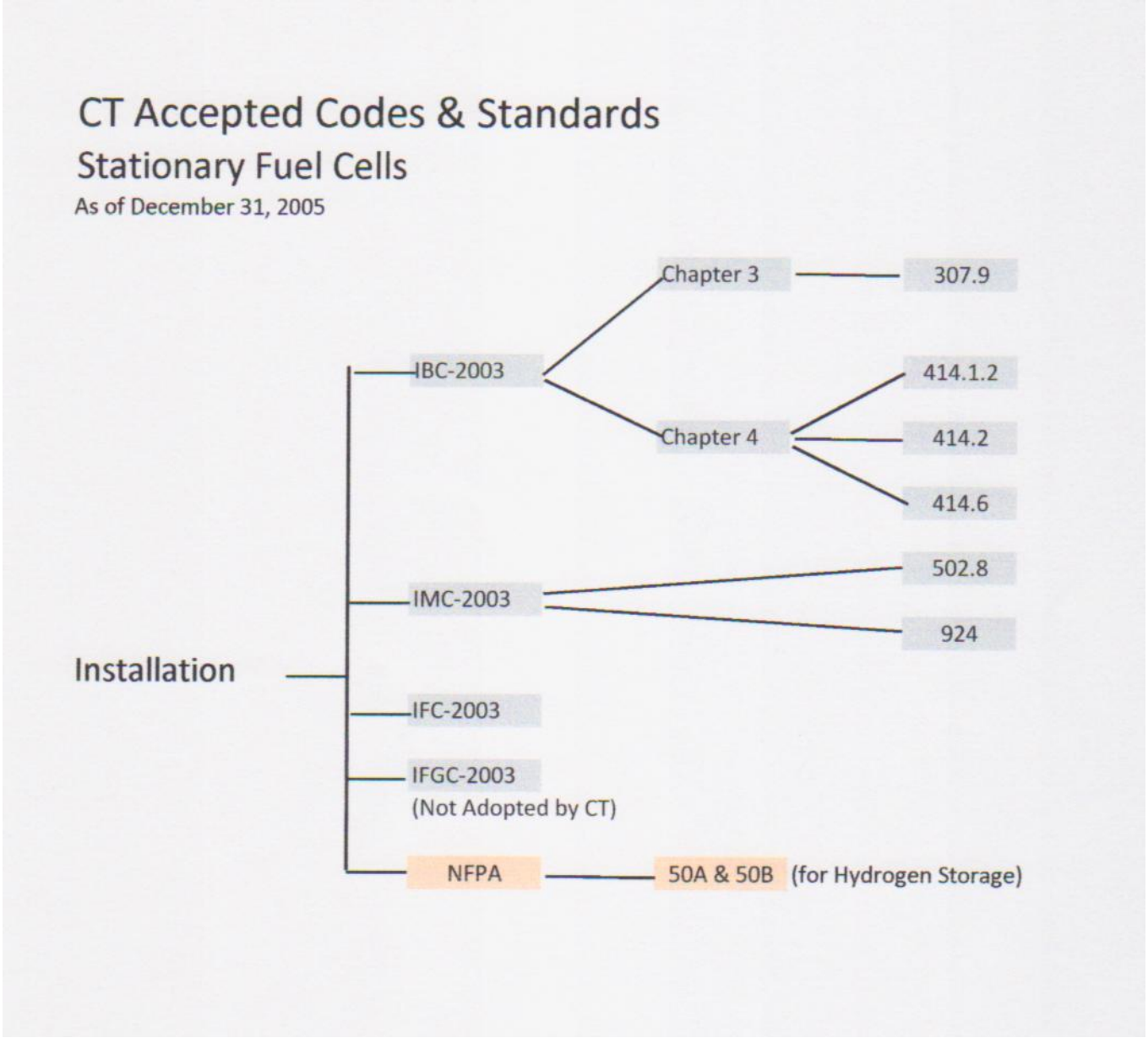
3. Hydrogen Storage – this may vary for each application depending upon if the hydrogen is liquid or gaseous, delivered to the station by truck or is generated through natural gas reforming or electrolysis on site. Typically some storage is furnished on site to have a supply available for dispensing.

Typical Pictures of Hydrogen Refueling Stations

As of January 1, 2008, the State of Connecticut has no codes or standards that specifically apply to hydrogen refueling stations. It is up to the local AHJ to use their judgment.

Enforceable Codes Standards for Hydrogen In Connecticut

The following diagram illustrates the various Codes & Standards (C&S) currently adopted and used by the State. A brief description of the C&S and how it addresses Hydrogen issues can be found in Appendix A of this Reference Guide.



Evolution of Codes & Standards for Hydrogen

Overview

Literally billions of cubic feet of hydrogen are consumed globally each year by industry in so-called “behind-the-fence” applications, such as in refineries. The use of hydrogen in a more public domain is a recent development based upon the need for alternative energy sources, energy security / energy independence, and environmental benefit considerations. These “new” applications primarily involve the use of fuel cell technology, which has been available since before the space program. Fuel Cell products have accumulated nearly 10 million hours of operation in hundreds of installations throughout the world and including a number in Connecticut. Like any fuel, hydrogen can be safely used. However, its unique physical characteristics warrant proper attention. Codes & Standards are fundamentally the means to ensure equipment and processes are properly

designed and operated to assure the public's safety. Just as the newer technologies associated with hydrogen are evolving, so are the codes & standards. The very difficult challenge is keeping codes and standards current and in sync with progress in deploying new hydrogen technology. How a jurisdiction responds to that challenge will dictate how hydrogen friendly it is for promoting the emerging hydrogen economy.

The challenge to building and fire safety codes is to make sure that they address the risks posed by hydrogen facilities. Public safety is primary while also providing the guidance to project developers needed to allow the safe deployment of these potentially beneficial hydrogen applications.

In the case of new technology, the existing building and fire safety codes may not address such new technology specifically. In such cases, a code administrator utilizes existing performance standards that apply safety principles and concepts to the specific characteristics of the new technology. Fortunately a great amount of study and testing is underway to define the risks and to define the appropriate design standards needed to protect the public.

As of December 31, 2005, the State of Connecticut uses the 2003 Edition of the ICC as its Codes for fuel cells installations

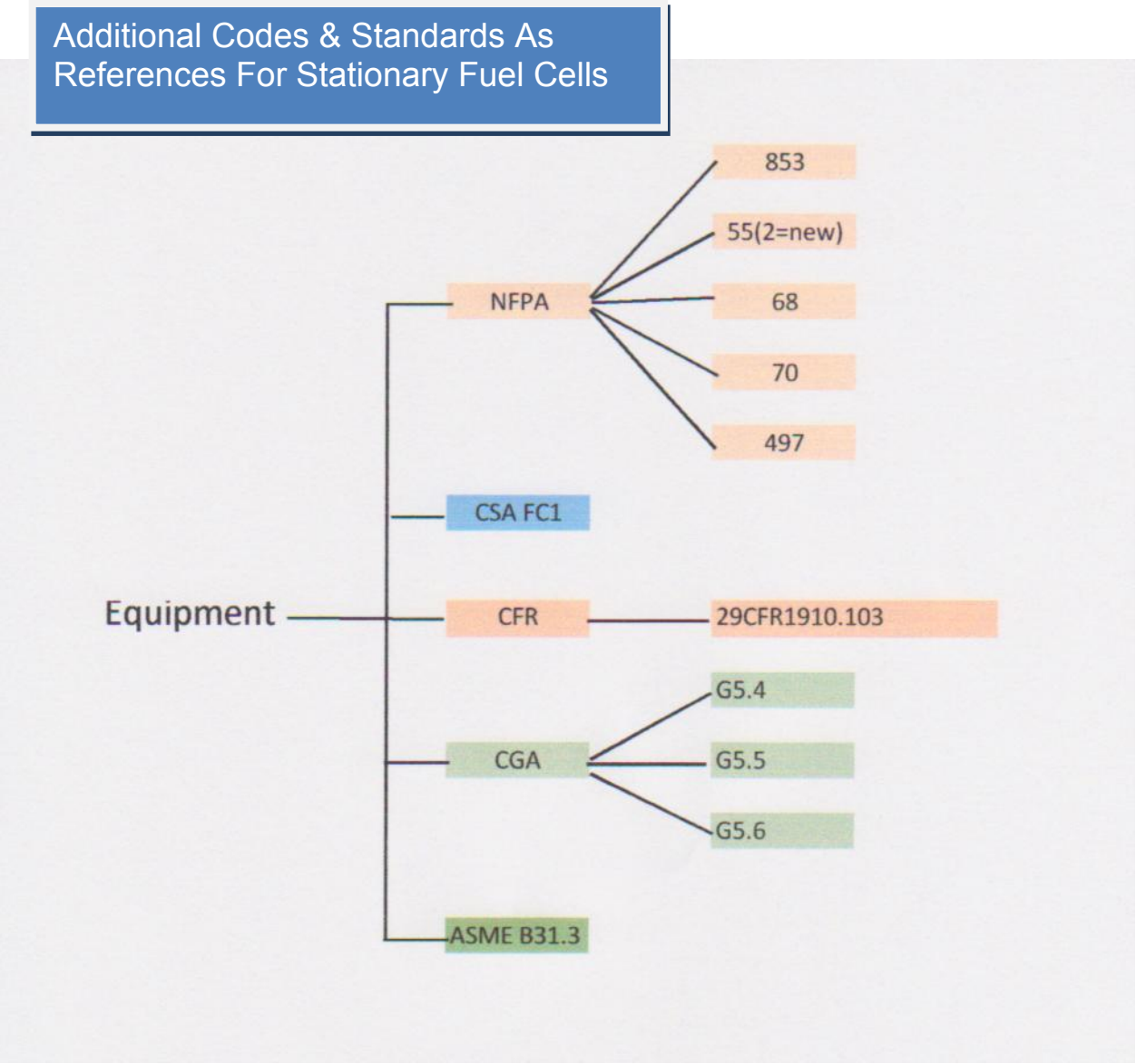
Although the 2006 ICC Codes are not adopted in Connecticut, they are often used as a guide for alternative materials and methods allowed by Section 104.11 of the 2003 IBC or as the basis of a building code modification per Section 104.10.1 of the 2003 IBC as amended by Connecticut.

Regulations, Codes, Standards, and For Information Only

The distinction between a "code" and a "standard" should be noted. Model building codes are guidelines for the design of the built environment (i.e., buildings and facilities). When model codes are adopted by state and local jurisdictions, they achieve the force of law. Codes often incorporate standards for the equipment used within the construction environment. A Standard clearly states the requirements and separates the mandatory requirements from the advisory text. Standards have no regulatory standing unless they are referred to in codes adopted by state and local jurisdictions or when incorporated in government regulations.

Future Expanison of Codes & Standards For Fuel Cells

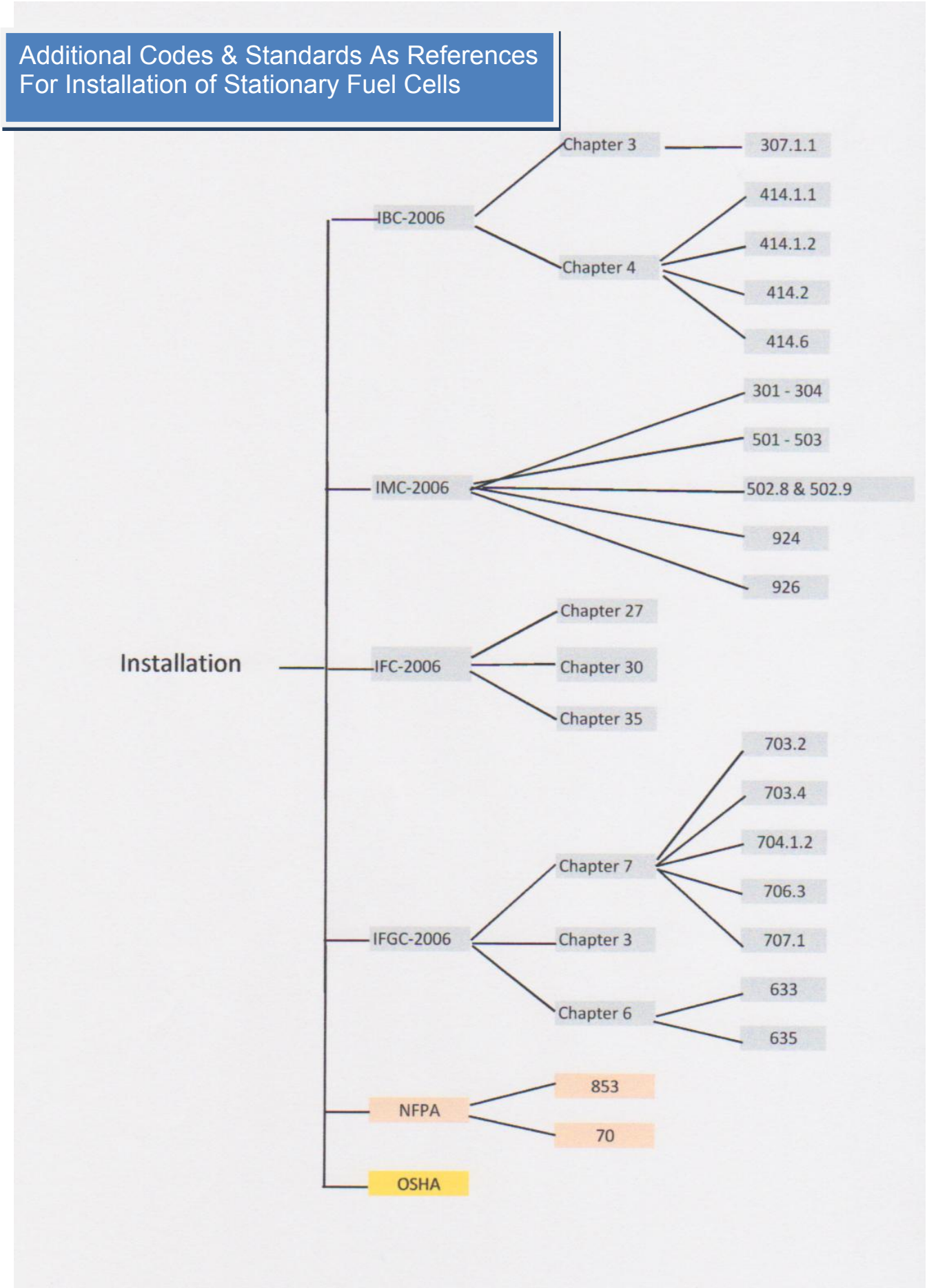
There is extensive work underway at the National and International levels to develop new code provisions and at the same time strengthen existing code treatment of hydrogen technology. The following graph illustrates some of the alternatives that are available as additional resources.



Note that the US is working with the International Organization of Standardds (ISO) to harmonize Hydrogen standards. Until that effort is completed, the ISO Standrads described in Appendix A of this Reportfior are for reference only.

Regarding the insallation of fuel cells, please note the following array of alternative resources:

Additional Codes & Standards As References For Installation of Stationary Fuel Cells



Equipment Suppliers' Position

The original equipment manufacturers (OEMs) have a slightly different position based upon the research for this Reference Guide. They tend to focus on the CSA America Standard For Stationary Fuel Cell Power Plants (ANSI/CSA America FC 1-2004), which was formerly known as ANSI Z21.83. This standard provides design, construction, operating and quality requirements for fuel cell power systems operating on:

A) A variety of fuels
B) At an output voltage not exceeding nominal 600 VAC or 600 VDC
C) And at a power output not exceeding 10 MW.

The manufacturers' products are certified to meet this Standard by third party organizations. The manufacturers have experience with using their equipment in many jurisdictions and are able to provide information to code officials.

In addition, they also utilize the International Code Council but the 2006 edition.

A worksheet from one OEM follows that identifies setbacks used and controlling reference.

2006 Editions of the International Building Code, International Mechanical Code and International Fuel Gas Code with references to the International Fire Code

Typical hydrogen storage siting criteria for quantities less than 4,226 standard cubic feet (scf) and 4,226 to 21,125 scf		**Controlling Code**	**Setback < 4,226 scf[a]**	**Setback 4,226 to 21,125 scf[a]**
Telecom Cabinets, Enclosures, and Telecom Equipment	RT cabinet; CPS cabinet; Power Pedestal; Transfer/Disconnect switches; BTS; BSC; AC meter	IFC Table 3504.2.1	5 ft	10 ft
Buildings on the same property	Non-rated construction or openings within 25 feet	IFC Table 3504.2.1	5 ft	10 ft
	2-hour construction and no openings within 25 feet	IFC Table 3504.2.1	0 ft	5 ft
	4-hour construction and no openings within 25 feet	IFC Table 3504.2.1	0 ft	0 ft
Underground flammable or combustible liquid storage, distance to vent or fill opening		IFC Table 3504.2.1	5 ft	10 ft
Ignition sources (including appliance burner igniters, hot work and hot surfaces capable of igniting flammable vapors)		IFC Table 3504.2.1	5 ft	10 ft
Overhead Electric utilities	Overhead electric wire	IFC Table 3504.2.1	5 ft	10 ft
	Overhead bus, trolley or train wire	IFC Table 3504.2.1	5 ft	10 ft
Public streets, alleys, ways		IFC Table 3504.2.1	5 ft	10 ft
Outdoor areas of public assembly		IFC Table 3504.2.1	5 ft	10 ft
Public sidewalks and parked vehicles		IFC Table 3504.2.1	5 ft	10 ft
Line of adjoining property that can be built upon		IFC Table 3504.2.1	5 ft	10 ft
Dry vegetation and combustible materials		IFC 2703.12/ 2704.11	15 ft	25 ft
Air intake openings		IFC Table 3504.2.1	5 ft	10 ft
Above ground flammable or combustible liquid storage	Diked, distance to dike	IFC Table 3504.2.1	5 ft	10 ft
	Not diked, distance to tank	IFC Table 3504.2.1	5 ft	10 ft
Additional flammable gas storage areas		IFC Table 3504.2.1	5 ft	10 ft

a. The minimum required distances shall not apply when fire barriers without openings or penetrations having a minimum fire-resistance rating of 2 hours interrupt the line of sight between the storage and the exposure. The configuration of the fire barrier shall be designed to allow natural ventilation to prevent the accumulation of hazardous gas concentrations.

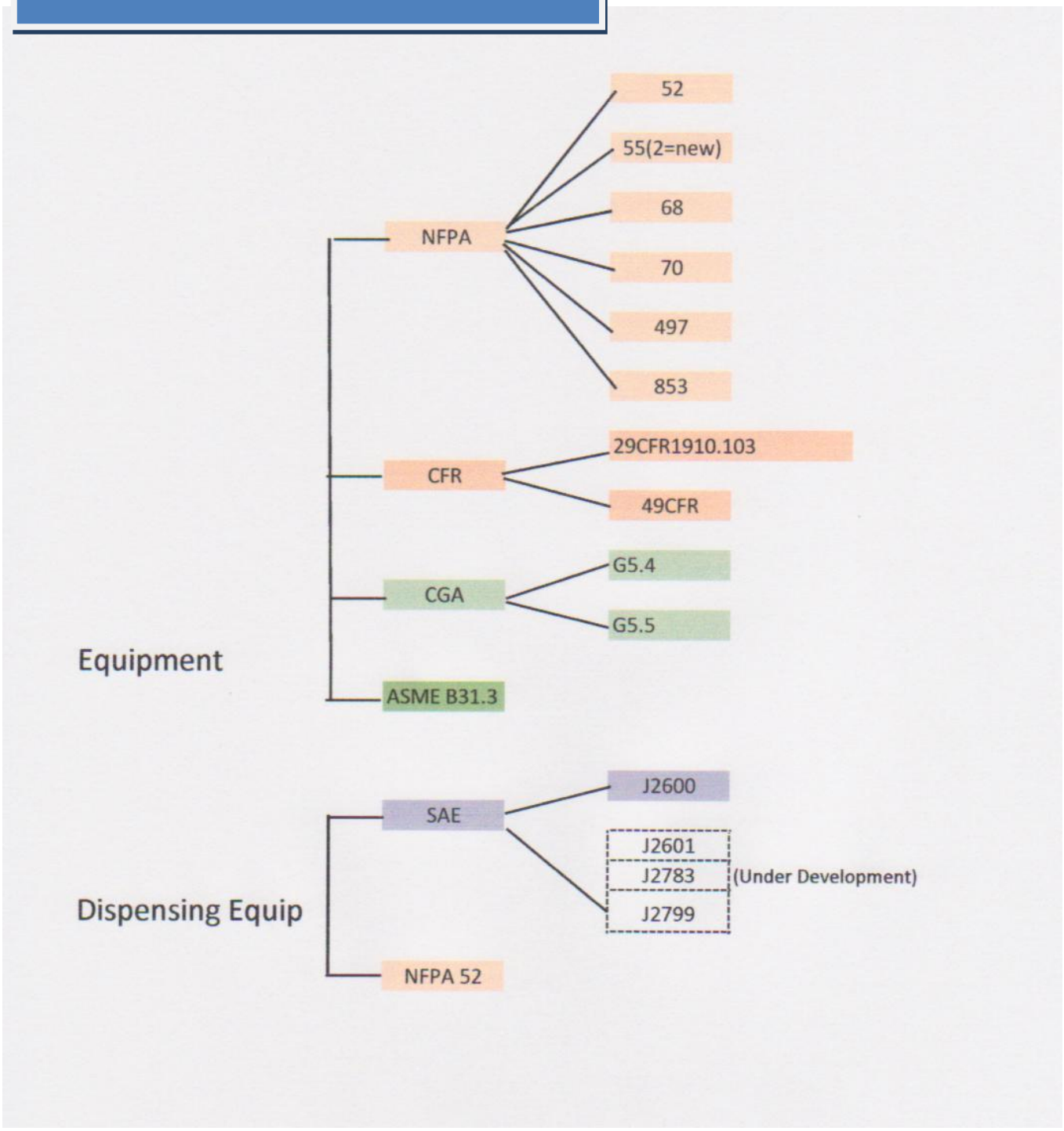
Note: Table provided by Plug Power

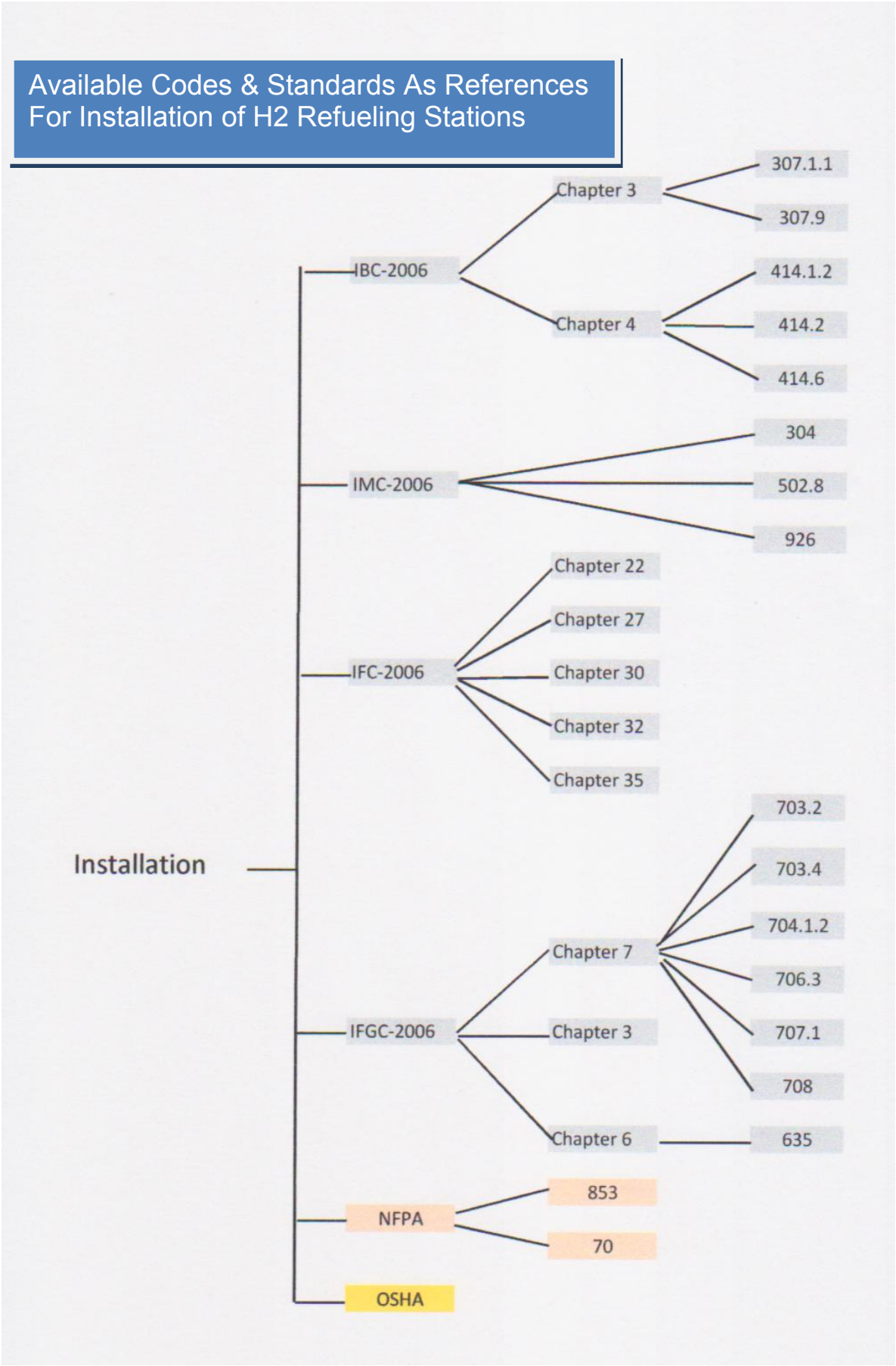
Hydrogen Refueling Stations

With an increasing number of Hydrogen refueling stations, the visibility of such stations to the public is also growing. Because of this factor and the fact that every car manufacturer and traditional vehicle fuel supplier has made and continues to make substantial investment in hydrogen technologies and infrastructure development, it is not surprising those developmental efforts for Codes & Standards for refueling stations are significant. It is also noteworthy that because the automobile industry is an integral part of global commerce, many of the C&S are being developed under ISO sponsored activities in order to establish worldwide acceptable standards.

The following graphs illustrate the array of C&S that are available today as resources when faced with permitting requests.

Available Codes & Standards As References For H2 Refueling Stations




Available Codes & Standards As References For Installation of H2 Refueling Stations
Installation
IBC-2006
Chapter 3
307.1.1
307.9
Chapter 4
414.1.2
414.2
414.6
IMC-2006
304
502.8
926
IFC-2006
Chapter 22
Chapter 27
Chapter 30
Chapter 32
Chapter 35
IFGC-2006
Chapter 7
703.2
703.4
704.1.2
706.3
707.1
708
Chapter 3
Chapter 6
635
NFPA
853
70
OSHA

Appendix A

Description of Codes and Standards

Appendix A- Description of Codes & Standards

As previously stated, since Codes & Standards are evolving and require consensus building among the many entities worldwide, there are many additional references an AHJ should use as resources for their evaluations. To help navigate through these references, categories of relative impact on hydrogen issues for each Regulation, Codes, and Standards has been assigned according to the following:

Primary Importance – having a direct impact
Secondary Importance – should be a consideration but not a deal breaker
Informational only – general reference
Tangential Importance – no direct impact but could have other considerations

The following describes the Regulation, Codes and Standards shown on the previous Reference graphs and briefly indicates their influence on Hydrogen.

Because Codes & Standards are evolving, it is suggested that the responsible standards organization's website be consulted to get the most recent updates

References for Stationary Fuel Cell Applications

Regulations

29 CFR; OSHA code influences hydrogen practice through how hydrogen is classified as a flammable gas (Part 1910.1000) and through requirements for siting of storage (1910.103), control on processes that use more than 10,000-lbs, training and labeling. (Category = Primary)

29 CFR 1910.103: This is the portion of OSHA code that pertains specifically to gaseous and liquid hydrogen systems. Its primary purpose is to codify hydrogen-siting requirements and to call out acceptable practice for storage systems. It is based almost completely on two NFPA codes; 50 A and 50 B which are referenced in the CFR. (Category = Primary)

Codes

International Code Council **-** The Family of International Codes consists of the following that specifically address hydrogen issues: (Category = Primary)

International Fire Code-2006 This portion of the ICC established minimum regulations for fire prevention and fire protection systems using prescriptive and performance-related provisions. (Category = Primary)

H2 Issues Addressed:
Chapter 22, Section 2209 defines the requirements for hydrogen motor-fuel-dispensing facilities and repair garages. Table 2209.3.1 provides a listing of separation distances. Also venting system requirements are defined. Chapter 30 established the requirements for compressed gas storage in containers, cylinders, tanks and gas cabinets and use and handling of compressed gases. Chapter 25 has a new section under the 2004 Supplement that addresses metal hydride storage systems.

International Mechanical Code – 2006 This portion of the ICC established minimum regulations for mechanical systems using prescriptive and performance-related provisions. (Category = Primary)

H2 Issues Addressed:
Chapter 5, which is also updated by the 2004 Supplement to the International Codes, defines exhaust system requirements specifically hydrogen limits in rooms and in cabinets as an acceptable concentration percentage of the total volume. Section 502 defines the ventilation requirements for repair garages while Section 510 describes the needs for hazardous exhaust systems. Chapter 9, Section 924 provides information on the installation and testing of stationary fuel cells.

Supplement to the International Codes -2004 This document identifies all the approved changes to the family of ICC codes that were released in 2003. (Category = Primary)

H2 Issues Addressed:
In addition to the changes noted above, this Supplement also identifies these references to hydrogen:

- ***International Building Code*** – Section 406.5.2.1 – Canopies used as weather protection for gaseous hydrogen systems (Category = Primary)
- ***International Electric Code*** – Section 1202.12 – Notes that stationary fuel cells power systems having a power output not exceeding 10 MW, shall be tested in accordance with ANSI, CSA, American FCQ and installed in accordance with the manufacturer's installation instructions and NFPA 853. (Category = Primary)
- ***International Fire Code*** – Section 2209 – Provides updates on emergency controls, venting, valving, and flow rates. (Category = Primary)
- ***International Fuel Gas Code*** – Sections 633 and 635 restates the directives for stationary fuel cells as provides in the Electric Code. Chapter 7 provides requirements for inspecting and testing gaseous hydrogen systems. (Category = Primary)

NFPA 2 – (Hydrogen Technologies). This is an extractive document, on track for 2010 code approval cycle. It compiles content from all other pertinent hydrogen sections of NFPA codes and contains original text on fuel cells, reformers, and water electrolyzers. (Category = future Primary)

NFPA 70 **-** 2008 Edition; National Electric Code. (Category = Secondary)
Issued as an American National Standard on 8/15/07; Revision estimated to be 2007. This edition is a NFPA Code.

H2 Issues Addressed:
Electrical classifications that apply to hydrogen as a gas and hydrogen as a liquid are in Chapter 5's special occupancies. Hydrogen is a Class I, Group B material per this code.

Article 250 covers grounding and bonding. The requirements for Class I, Divisions 1 and 2 locations are covered in Articles 500 and 501. Article 504 covers the installations of intrinsically safe apparatus, wiring and systems. Article 505, zone classification system is the alternative to division classification systems. Articles 511 through 517 cover occupancies that may be hazardous due to atmospheric concentrations of flammable liquids, gases or vapors. In Article 692 the requirements of fuel cell power systems include circuit requirements, disconnecting means, wiring, grounding, and marking.

NFPA 72 - 2007 Edition**;** National Fire Alarm Code (Category = Secondary)
Issued as an American National Standard on 8/17/06, this document dates back to 1898. Revision estimated to be completed in 2005. This edition is a NFPA Code.

H2 Issues Addressed:
Requirements for signaling components and signaling systems are covered. Primary function is to provide notification of a fire (hydrogen gas that has ignited). Also, to provide supervisory and trouble signals, to alert occupants, to summon aid, and to control fire safety functions.

NFPA 101 - 2006 Edition; Life Safety Code (Category = Secondary)
Issued as an American National Standard on 7/27/05. This edition is a NFPA Code.

H2 Issues Addressed:
Hydrogen is a high hazard occupancy as it is likely to burn with extreme rapidity thus requiring special provisions in egress, fire protection, interior finishes, and building services.

<u>Standards</u>

CSA America Standard For Stationary Fuel Cell Power Plants was approved by ANSI as ANSI/CSA America FC 1-2004. *(formerly known as ANSI Z21.83) (Category = Primary)*

H2 Issues Addressed:
This standard provides design, construction, operating and quality requirements for fuel cell power systems operating with a variety of fuels at an output voltage not

exceeding nominal 600 VAC or 600 VDC and at a power output not exceeding 10 MW. This is the Standard used by most fuel cell manufacturers for their equipment.

NFPA 55 – 2008 Edition (2009 Edition available as a draft); Standard for the Storage, Use, and Handling of Compressed Gases and Cryogenic Fluids in Portable and Stationary Containers, Cylinders, and Tanks (Category = Secondary)

The 2008 Edition was issued as an American National Standard on 8/15/07. It incorporates two other documents in Chapters 10 and 11 respectfully, 50A (Gaseous Hydrogen Systems at Consumer Sites) and 50B (Liquefied Hydrogen Systems at Consumer Sites) that have been withdrawn from publication. This edition is a NFPA Standard not a Code. This is a guidance document provided for the AHJs and for the States to adopt as their Code.

H2 Issues Addressed:
Requirements are on the storage, transfer, location, and use of industrial hydrogen either as a gas or as a liquid. Included are the requirements for the installation of associated storage, piping, and distribution equipment; operating practices, installation of aboveground & fire-resistant tanks, dispensing & required building construction, electric classifications, and operational requirements.

This standard does not apply to portable gas containers having a total liquefied hydrogen content of less than 11 cubic meters (400scf) if separated by 5 ft. or to liquefied portable hydrogen containers of less than 39.7 gallons (150 Liters).

NFPA 496 - 2003 Edition*;* Standard for Purged and Pressurized Enclosures for Electrical Equipment (Category = Secondary)
Issued as an American National Standard on 7/18/03; Revision estimated to be in 2008. This is a guidance document.

H2 Issues Addressed:
Purging and pressurizing of electrical equipment in classified high hazard area as defined by NFPA 70's Article 500 or 505 apply to hydrogen as a gas and as a liquid are covered. Requirements for pressurized control rooms, enclosures and analyzer rooms are included.

NFPA 853 - 2007 Edition; Standard for the Installation of Stationary Fuel Cell Power Systems (Category = Primary)
American National Standard on 8/17/06. Revision estimate to be completed in 2006. This edition is a NFPA Standard not a Code, but a guidance document.

H2 Issues Addressed:
Fuel cell design, construction and installation requirements of a singular or any combination of self-contained pre-packaged power systems, two or more factory-matched modular components, and engineered field-constructed power systems. Fuel systems would be hydrogen, CNG, or LPG.

NFPA 10 - 2007 Edition*;* Standard for Portable Fire Extinguishers (Category = Secondary)
Issued as an American National Standard on 8/17/06. Revision estimated to be completed in 2006. This edition is a NFPA Standard not a Code.

H2 Issues Addressed:
Requirements to select, install, and maintain portable fire extinguishing equipment based on the classification of hazards. Class B fire extinguishers are used for pressurized flammable liquids and pressurized gas fires only if there is reasonable assurance that the source of fuel can be turned off.

NFPA 13 - 2007 Edition*;* Standard for the Installation of Sprinkler Systems (Category = Secondary)
Issued as an American National Standard on 8/1706. Revision estimated to be finalized in 2006. This edition is a NFPA Standard not a Code and should be considered a guidance document.

H2 Issues Addressed:
Requirements to classify an occupancy, design, install automatic sprinkler systems. Article 13.11, Figure 11.2.3.1.1 provides the design requirements when required by NFPA 55 in 6.9.2 Sprinkler System Design.

NFPA 45 - 2004 Edition; Standard on Fire Protection for Laboratories Using Chemicals (Category = Informational)
Issued as an American National Standard on 8/5/04; Revision estimated to be completed in 2009. This edition is a NFPA Standard not a Code and should be considered a guidance document.

H2 Issues Addressed:
Laboratory unit fire hazard classification is based on the quantities of flammable gases present and NFPA 704's rating of the material hazard. Chapter 11 covers compressed and liquefied gases. The design, fire protection, and ventilation requirements are covered.

NFPA 69 - 2008 Edition*;* Explosion Prevention System (Category = Secondary)
Issued as an American National Standard on 8/15/07. This edition is a NFPA Standard not a Code and should be considered a guidance document.

H2 Issues Addressed:
Requirements for installing systems to prevent explosions by prevention or control of deflagrations in enclosures that contain flammable concentrations of gases.
NFPA 704 - 2007 Edition; Standard System for the Identification of the Hazards of Materials for Emergency Response (Category = Secondary)
This standard system identifies material hazards for emergency response personnel since 1961. Issued as an American National Standard on 8/17/06.. This is a guidance document.

H2 Issues Addressed:
Hydrogen is a 3-4-0 [Health-Flammability-Instability ratings where 4 is the highest degree of hazard] with a required DOT shipping label "Class 2.1, Flammable Gas" and an ID NO. UN 1966 refrigerated liquid. [This chemical's entry in DOT's Hazardous Materials Table for recommended emergency action procedure.]

ISO 14687 Hydrogen fuel – Product specification (1999, Cor 1 - 2001) under revision (Cor 2 and FDTS 14687-2) (Category = Informational)

This International Standard specifies the quality characteristics of hydrogen fuel in order to assure uniformity of the hydrogen product as produced and distributed for utilization in a vehicular, appliance, or other fueling applications. It delineates hydrogen fuel grades and purity specifications.

CGA G-5.3 Commodity Specification for Hydrogen, Edition: 5
Published: 8/3/2004 (Category = Secondary)

This document describes the current commodity specification for gaseous and liquid hydrogen product. The document also provides pertinent information on methods of analysis and sampling technique, quality verifications, typical-use tables, as well as supplemental graphs and data tables.

CGA G-5.4 Standard for Hydrogen Piping at Sites (2001) (Category = Secondary)

This standard describes the specifications and general principles recommended for piping systems for either gaseous (Type I) or liquid (Type II) hydrogen on premises, beginning at the point where hydrogen enters the distribution piping (the battery limits of the hydrogen storage system) at service pressure to the use point of the hydrogen.

CGA G-5.5 Hydrogen Vent Systems (2004 Second Edition) (Category = Secondary)

This document presents design guidelines for hydrogen vent systems for gaseous and liquid hydrogen systems at consumer site and provides recommendations for their safe operation.

CGA G-5.6 Hydrogen Pipeline Systems (2005) (Category = Secondary)

This Standard is a joint European Industrial Gases Association (EIGA)/CGA international harmonized standard on metallic transmission and distribution piping systems carrying pure hydrogen and hydrogen mixtures.

IEC 62282-3-3 International Electrotechnical Commission regarding Fuel Cell Power Systems– Installation (2007) (Category = Secondary)

Provide performance based requirements for the minimum safe installation of indoor and outdoor fuel cell power plants.

Recommended Practices

NFPA 68 - 2007 Edition; Guide for Venting of Deflagration (Category = Secondary)
Issued as an American National Standard on 12/20/06. This edition is a design guide, not a code or a standard.

H2 Issues Addressed:
Applies to explosion protection systems for all types of equipment and for buildings but not to pressure venting devises such as pressure relief valves and rupture discs. Table D.1(a) shows hydrogen's fundamental burning velocity is 312 cm/sec compared to gasoline's 40 and propane's 46. Table E.2 has the maximum pressure developed in a 5liter (0.005 cubic meter test sphere of 6.8 bars compared to propane's 7.9 – this data is used for design calculations for deflagration vents.

NFPA 497 - 2004 Edition; Recommended Practice for the Classification of Flammable Liquids, Gases, or Vapors and of Hazardous (Classified Locations for Electrical Installations in Chemical Process Areas (Category = Secondary)
Issued as an American National Standard on 1/16/04; Revision estimated to be 2008. This edition is a NFPA Recommended Practice (Not a Code or a Standard).

H2 Issues Addressed:
Electrical classifications apply to hydrogen (Class I, Group B) as a gas and hydrogen as a liquid where a release could be ignited. Procedure and extent of the classified location, diagrams, and basis for recommendations are covered.

AIAA G-095-2004; Safety of Hydrogen and Hydrogen Systems (Category = Secondary)

This AIAA Guide is an ANSI approved industry consensus document based on the National Aeronautics and Space Administration (NASA) document "Safety Standard for Hydrogen and Hydrogen Systems", NASA Safety Standard (NSS) 1740.16. The guide provides a practical and comprehensive set of guidelines for safe hydrogen use as either a gas or as a liquid.

NFPA 77 - 2000 Edition; Recommended Practice on Static Electricity (Category = Informational)
Issued as an American National Standard on 8/18/00. Revision estimated to be completed in 2007.

H2 Issues Addressed:
Requirements for reducing the fire hazard from static electricity. Its nature and origin, mitigation methods, and ways to dissipate the charge are discussed.

NFPA 901 - 2006 Edition; Standard Classifications for Incident Reporting and Fire Protection Data (Category = Informational)
Issued as an American National Standard on 2/9/01; Revision estimated to be completed in 2007.

H2 Issues Addressed:
Feedback information would be available based on the reporting and fire protection data resulting from other facilities where a hydrogen fire occurred.

ISO/TR 15916 Basic consideration for the safety of hydrogen systems (2004) (Category = Information)

This Technical Report provides guidelines for the use of hydrogen in its gaseous and liquid forms. It identifies the basic safety concerns and risks, and describes the properties of hydrogen that are relevant to safety. This document was prepared as the “cornerstone” for general hydrogen safety considerations. Detailed safety requirements associated with specific hydrogen applications are treated in separate International Standards.

ISO 22734-1 Hydrogen generators using water electrolysis process (Category = Informational)

This Standard defines the construction, safety and performance requirements of packaged or factory matched hydrogen gas generation appliances, herein referred to as hydrogen generators, using electrochemical reactions to electrolyze water to produce hydrogen and oxygen gas. It is applicable to hydrogen generators intended for indoor and outdoor commercial and industrial use (non-residential use). Hydrogen generators that can also be used to generate electricity such as reversible fuel cells are excluded from the scope of this International Standard. It is intended to be used for certification purposes.

Note ISO 22734-2 will be issued for residential applications

ISO 16110-1 Hydrogen generators using fuel-processing technologies Published in 2007 (Category = Informational)

The draft of this International Standard applies to packaged, self-contained or factory matched hydrogen generation appliances, referred to as hydrogen generators, that convert a hydrocarbon fuel to a hydrogen rich stream of composition and conditions suitable for the type of device (e.g. fuel cells) using the hydrogen.

ISO 16111 Transportable gas storage devices — Hydrogen absorbed in reversible metal hydrides
Published 2006 (Category = Informational)

This standard addresses the safe design and use of transportable hydrogen gas storage canisters including all necessary valves, relief devices, and appurtenances, intended for use with reversible metal hydride, hydrogen storage systems. This standard only applies to refillable devices where hydrogen is the only transferred media. Transportable gas storage devices do not include devices intended as fixed on-board fuel storage for hydrogen fueled vehicles.

The requirements of this standard are not intended to constrain innovation. The manufacturer may consider materials, designs or constructions not specifically dealt with in this document. Components used in transportable hydrogen gas storage devices may not be within the size limitations of the standards referenced in this document. These alternatives shall be evaluated as to their ability to yield levels of safety and performance equivalent to those prescribed by this standard.

CGA G-5: Hydrogen, Edition: 5 Published: 10/2/2002 (Category = Informational)

A complete monograph with physical properties is included, as well as how hydrogen is made, used, contained and transported. This publication complements G-5.4, G-5.5, and G-5.6 to ensure safe and effective hydrogen installations.

*CGA H-*1 Edition: 1 Title: Service Conditions for Portable, Reversible Metal Hydride Systems Published: 8/24/2004 (Category = Informational)

This publication outlines the service conditions expected for the system and various system components in a portable, reversible metal hydride system. These systems do not include metal hydride battery systems.

CGA H-2 - 2004 (First Edition 2004): Title: Guidelines for the Classification and Labeling of Hydrogen Storage Systems with Hydrogen Absorbed in Reversible Metal Hydrides Published: 8/24/2004 (Category = Informational)

Hydrogen storage systems based on reversible metal hydride technology are being introduced for consumer use. Due to the lack of appropriate regulations, codes and standards and experience for this emerging technology, there is the potential for inconsistency in their classification, labeling, and treatment for shipping and installation. This document gives guidance to regulators, manufacturers, and users of these systems to establish a consistent and uniform basis for the classification, labeling, and treatment of such products.

CGA PS-17 Edition: 2 Title: CGA Position Statement on Underground Installation of Liquid Hydrogen Storage Tanks Published: 9/29/2004 (Category = Informational)

This publication clarifies statements within CGA P-12 and CGA G-5.4 that are viewed as prohibitions to below grade installation of liquid hydrogen. In addition to industry's position based on experience, it also provides general design and installation minimum criteria for such installations.

CGA P-6 Edition: 5 Title: Standard Density Data, Atmospheric Gases and Hydrogen Published: 3/8/2000 (Category = Informational)

Density data recommended in this publication were developed by the Compressed Gas Association to provide uniform values of liquid and gas density for atmospheric gases and hydrogen for the benefit of suppliers and users of these commodities. Tables present standard density data and volumetric conversion factors.

CGA P-12 Edition: 3 Title: Safe Handling of Cryogenic Liquids Published: 1/1/1993 (Category = Informational)

A general guide to the safe handling of cryogenic liquids commonly used in industry, including their properties, safety standards, general safety practices and first aid procedures, fire prevention and fire fighting procedures, and recommendations for safe handling of these liquids in containers and storage systems. Intended for use by consumers, shippers, carriers, distributors, and others who want an introduction to cryogenic liquids.

CGA P-28 Edition: 2 Title: Risk Management Plan Guidance Document for Bulk Liquid Hydrogen Systems Published: 12/8/2003 (Category = Informational)

The EPA Risk Management Plan (RMP) rule applies to the storage and use of listed substances including liquid hydrogen when the inventory of the process equals or exceeds 10,000 lbs. This publication provides information and expert guidance to help liquid hydrogen users comply with the RMP rule. It includes a typical system flow diagram; a typical hazard and operability (HAZOP) study, and information, tables, and charts to help users of liquid hydrogen carry out the required hazard assessment efficiently. The tables and charts allow the user to look up worst-case and alternative-case distances directly.

Additional References for Hydrogen Refueling Station Considerations

Regulations

49 CFR; The transportation code (DOT) has specific requirements for the transportation of hydrogen as a compressed gas or cryogenic liquid and for the mode of transportation (by road, rail, sea, or air). (Category = Primary)

Codes

NFPA 30A **-** 2003 Edition; Code for Motor Fuel Dispensing Facilities and Repair Garages (Category = Informational)
Issued as an American National Standard on 7/18/03; Revision estimated to be completed in 2007.

H2 Issues Addressed:
Applies to liquid motor fuels and 3 gases. H2 is not mentioned but other gases are in new Chapter 12; CNG, LNG, &LP-Gas. Requirements are on above ground and fire-resistant tanks, dispensing piping and required building construction, electric classifications, and operational requirements.

Standards

NFPA 52-- 2006 Edition; Vehicular Fuel Systems Code applies to the design, installation, operation, and maintenance of compressed natural gas (CNG) and liquefied natural gas (LNG) engine fuel systems on vehicles of all types and for fueling vehicle (dispensing) systems and associated storage. Revisions estimated to be 2009. This is a NFPA code. (Category = Secondary)

This was issued as an American National Standard on August 18, 2005. It now incorporates NFPA 57, LNG Fuel System Code, in this edition with new chapters addressing hydrogen topics that relate to vehicular fuel systems.

H2 Issues Addressed:
NFPA 52 addresses requirements on general gaseous hydrogen and equipment qualifications, service and maintenance of gaseous hydrogen engine fuel systems, gaseous hydrogen compression, gas processing, storage, and dispensing systems, and liquefied hydrogen fueling facilities.

SAE J2600; Compressed Hydrogen Surface Vehicle Refueling Connection Devices
Published: October 2002 (Category = Secondary)

SAE J2600 applies to design, safety and operation verification of Compressed Hydrogen Surface Vehicle (CHSV) refueling connection devices hereinafter referred to as nozzle and receptacle. CHSV Refueling nozzles and receptacles shall consist of the following components, as applicable. This document applies to devices that have working pressures of 25 MPa, 35 MPa, 50 MPa or 70 MPa. For the purposes

of this document, compressed hydrogen gas should meet the requirements of ISO 14687 Hydrogen fuel - Product specification.

ISO 13984 Liquid hydrogen – Land vehicle fueling system interface (1999) (Category = Informational)

This International Standard specifies the requirements for the fueling system interface for refillable tanks for liquid hydrogen used as fuel in land vehicles.

ISO 13985 Liquid hydrogen—Land vehicle fuel tanks (2006) (Category = Informational)

This International Standard specifies the construction requirements for refillable fuel tanks for liquid hydrogen used in land vehicles. It also identifies the testing methods required to provide a reasonable level of protection from loss of life and property resulting from fire and explosion.

ISO/PAS 15594 Airport hydrogen fuelling facility operations (2004) (Category = Informational)

This standard specifies the fueling procedures, hydrogen boil-off management procedures, hydrogen storage requirements, and characteristics of the ground support equipment required to operate an airport hydrogen fueling facility.

Recommended Practices

ISO 17268 Gaseous hydrogen — Land vehicle filling connectors In progress: ISO/TC 197 WG 5 (Category = Informational)

ISO 17268:2006 applies to design, safety and operation verification of Compressed Hydrogen Surface Vehicle (CHSV) refueling connection devices referred to as nozzle and receptacle. CHSV Refueling nozzles and receptacles consist of the following components, as applicable:

- Receptacle and protective cap (mounted on vehicle); and
- Nozzle.

ISO 17268:2006 applies to devices which have working pressures of 25 MPa and 35 MPa, It applies to nozzles and receptacles which (1) prevent hydrogen fuelled vehicles from being refueled by dispenser stations with working pressures higher than the vehicle; (2) allow hydrogen vehicles to be refueled by dispenser stations with working pressures equal to or lower than the vehicle fuel system working pressure; (3) prevent hydrogen fuelled vehicles from being refueled by other compressed gases dispensing stations; and (4) prevent other gaseous fuelled vehicles from being refueled by hydrogen dispensing stations.

ISO/DIS 15869.3 Gaseous hydrogen and hydrogen blends —Land vehicle fuel tanks (5 part standard) In progress: ISO/TC 197 WG 6 (Category = Informational)

This International Standard specifies minimum requirements for serially produced light-weight refillable gas tanks intended only for the on-board storage of high pressure compressed gaseous hydrogen or hydrogen blends as fuels for land vehicles to which the tanks are to be fixed.

This International Standard covers tanks of any steel, aluminum or non-metallic material construction, using any design or method of manufacture suitable for the specified service conditions. This part of ISO 15869 defines the common aspects of all tanks covered in ISO 15869. Specific aspects, which may modify or supplement the common aspects and therefore cannot stand alone, are given in the following individual parts:

. Type 1 - Metal tanks in ISO 15869-2;
. Type 2 - Hoop wrapped composite tanks with a metal liner in ISO 15869-3;
. Type 3 - Fully wrapped composite tanks with a metal liner in ISO 15869-4;
. Type 4 - Fully wrapped composite tanks with non-metallic liner in ISO 15869-5.

Appendix B

Appendix B

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- Mr. Paul Buehler, Plug Power
- Mr. Peter Hobbs, Newington Building Inspector
- Mr. Denys Shorthouse, Glastonbury Building Inspector

References

The following References were used as part of the research for this project:

- "Applying Local Building and Fire Safety Codes to Hydrogen Technology Applications In New York State", Report prepared for The New York State Energy Research and Development Authority by Pace Law School Energy Project and Hydrogen Safety, LLC
- 2006 I-Codes Application Matrix, Stationary Hydrogen Fuel Cell Installation with Outdoor Hydrogen Storage, NHA Fuel Cell Seminar, San Antonio, TX Oct 2007 by Davidson Code Concepts
- DOE's Fuel Cell Standards website at www.fuelcellstandards.com
- Fuel Cells 2000 website

Additional References

- Study of the feasibility of Utilizing Fuel Cells to Generate Power for the New Haven Rail Line by Connecticut Academy of Science and Engineering (CASE), August 2007
- Preparing for the Hydrogen Economy: Transportation by Connecticut Academy of Science and Engineering (CASE), 2006

Lexicon for Codes & Standards Organizations

ANSI – American National Standards Institute

ASME – American Society of Mechanical Engineers

CFR – Code of Federal Regulations

CGA – Compressed Gas Association

CSA – Canadian Standards Association

ICC – International Code Council

IBC - International Building

IEC - International Electric Code

IFC - International Fire Code

IFGC - International Fuel Gas Code

ISO – International Organization of Standards

NFPA – National Fire Protection Association

OSHA – Occupational Safety and Health Administration

SAE – Society of Automotive Engineers