

## Appendix B

### Hydrogen Fuel Method of Sale

#### Table of Contents

	<b>Page</b>
U.S. National Work Group for the Development of Commercial Hydrogen Measurement Standards Fuel Specifications Subcommittee (FSS) Proposed Method of Sale and Quality Specification for Hydrogen Vehicle Fuel .....	B2
BP Global Fuels Technology .....	B15
U.S. Fuel Cell Council .....	B16
UTC Power .....	B17
Van Putten-Blue Energy Observatories .....	B19
California Fuel Cell Partnership .....	B20
Daimler AG .....	B21

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**U.S. National Work Group for the  
Development of Commercial Hydrogen Measurement Standards**

**Fuel Specifications Subcommittee (FSS)  
A Proposed Method of Sale and Quality Specification  
for Hydrogen Vehicle Fuel**

**Summary of Current Information**

The Chairman of the FSS is: Mr. Robert W. Boyd, Linde North American, Inc.

- a. Initially, the proposed method of sale and quality specification for hydrogen vehicle fuel was presented at the Western (WWMA) and Southern (SWMA) Weights and Measures Association Annual Meetings in the fall of 2008. The proposal was adopted with a recommendation that it be submitted as an Informational item on the National Conference of Weights and Measures (NCWM) Laws and Regulations (L&R) agenda at the 2009 Interim Meeting, which was held January 11 - 14, 2009, in Daytona Beach, Florida. This item was also presented at the two remaining regions, the Central (CWMA) and Northeastern (NEWMA), Annual Conferences in the spring of 2009. The proposal was again presented at the 2009 NCWM Annual Conference, held July 12 - 16, 2009 in San Antonio, Texas.
- b. The recommendations of the FSS, based on the subcommittee's April 2009 review of the proposed method of sale for hydrogen engine fuel are:
  - i. The FSS agreed to use the current proposal as a foundation for the fuel quality standard for hydrogen. The FSS will continue to consider further refinement of the definitions for hydrogen vehicle fuel based on input from SAE International should they be deemed necessary to finalize the standard.
  - ii. The FSS noted that Federal Trade Commission's (FTC) Fuel Rating Rule (16 CFR Part 309), see the requirements in "Labeling of Alternative Fuels" (<http://www.ftc.gov/bcp/edu/pubs/business/autos/bus29.shtm>), requires dispensers to bear a declaration of minimum hydrogen content determined according to the test methods described in "Standard Test Method for Analysis of Natural Gas by Gas Chromatography (ASTM D1946-90)."
  - iii. The FSS further modified the proposed HB 130 language to recognize the language in 16 CFR Part 309.15 Posting of non-liquid alternative vehicle fuel rating.

**Section I. Prologue**

The discussion paper that follows is "The Starting Point: A Discussion Paper Describing a Proposed Method of Sale and Quality Specification for Hydrogen Vehicle Fuel" originally published in June 2008. The corresponding proposals are for the method of sale and fuel quality.

This paper describes proposals for a uniform method of sale and fuel quality specifications on hydrogen vehicle fuels that are under development by the USNWG Fuel Specifications Subcommittee (FSS). The

purpose of this document is to organize, focus, and record the work of the FSS. Participation in the work of the subcommittee is open to anyone intending to make a positive contribution to the process

The States have always had a leadership role in establishing and enforcing the laws and regulations for legal metrology and fuel quality in the United States. The goal of this effort is to develop proposals for inclusion in NIST Handbook 130, “Uniform Laws and Regulations in the areas of Legal Metrology and Engine Fuel Quality,”<sup>1</sup> which is a source for model laws that the States use in developing their legal requirements. Some states adopt the regulations in that handbook by reference or citation in law. This approach has provided national uniformity in regulation of a number of significant issues, including packaging and labeling, net quantity of contents, and fuel quality.

The FSS includes hydrogen producers, dispenser and component manufacturers, weights and measures, air resource, fuel quality officials, and other interested parties. This document is presented to invite comments from automotive and fuel cell manufacturers, marketers, weights and measures, and other state officials and other experts who certainly will have questions, concerns, and suggestions as these proposals are developed in the NCWM – L&R Committee.

The members of the FSS recognize that when small groups develop standards for emerging technologies it is impossible to be knowledgeable about all aspects of a subject which is, by its nature, changing even as a meeting takes place or a report of its progress is being composed. With this in mind, please review this document and contribute your knowledge, understanding, and ideas to this effort.

## **Section II. Method of Sale and Fuel Quality Standard**

Participants at the first FSS meeting in March 2008, considered a proposal for a Method of Sale for Hydrogen Fuel that was prepared by NIST. Recent FSS work to update the proposed Method of Sale requirements are presented below. Also discussed was the need for a quality standard. The basis for that discussion was the proposed Hydrogen Fuel Standard developed by the California Department of Food and Agriculture; Division of Measurement Standards (CDFA/DMS) contained in a March 3, 2008, regulatory notice.<sup>2</sup> The FSS recognizes and commends the State of California for sharing its knowledge and experience in providing a starting point for a national standard for hydrogen fuel. This document should be interpreted as neither an endorsement, nor criticism, of the CDFA/DMS proposal by either the FSS or NIST unless otherwise stated. For the most recent FSS updates on the fuel quality proposal, refer to Section III.

### **Uniform Method of Sale for Hydrogen Vehicle Fuel**

Defining a legal requirement for a uniform method of sale for commodities is the most practical and efficient way that weights and measures uses to ensure that consumers can make value comparisons between competing sellers of the same commodity. The purpose is to ensure that purchasing decisions enable consumers to obtain the greatest value for their money. A uniform method of sale also ensures that sellers advertise and deliver a commodity using a single unit of measurement so comparisons can be quick and simple. Typically commodities (e.g., gasoline, diesel fuel, food, milk, wine, sand and gravel, and others) are sold by weight, measure (volume or dimensions, including area), or count.

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<sup>1</sup> See the 2009 Edition of NIST HB 130 at <http://www.nist.gov/owm>

<sup>2</sup> Available at <http://www.cdca.ca.gov/dms/hydrogenfuel/hydrogenfuel.html>

Establishing a method of sale for any product is a critical first step in the development of a fair and competitive marketplace for any commodity, especially one that is just emerging and for which there is not a traditional method of sale for the commodity on which to build. History has shown that when products are introduced into the marketplace without a legally defined standard, confusion and unfair competitive practices can quickly evolve and potentially harm the consumer's perception of the product and business reputation of the seller.

The need for a method of sale was stated in the 2005 "Hydrogen Delivery Technology Roadmap,"<sup>3</sup> which called on retailers and appropriate government agencies to establish a legal unit of measurement for hydrogen (see endnote<sup>i</sup> for further discussion).

**The FSS recommends that all retail sales of hydrogen vehicle fuel be by mass using the kilogram as the unit of measurement.**

The industry's pre-market practice has been to dispense hydrogen using the kilogram as the unit of measurement. The use of mass was strongly favored by the FSS participants who agreed that it should be the basis for retail commercial transactions. By requiring use of the kilogram as the unit of measurement for all retail dispensers, consumers can make value comparisons between competing retailers. Dispensing hydrogen by mass using the kilogram is specified in Section 2.4.2. Indications of OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles" (Edition 2007) and is the method of sale used in other countries so the U.S. method of sale will be consistent with that used in the global marketplace. As this fuel becomes fully commercialized, consumers considering the lease or purchase of a hydrogen vehicle will need to learn the fueling process for their hydrogen vehicle and be educated that their fuel purchases will be made on the basis of mass using the kilogram. The FSS considered, but does not support, a gasoline gallon equivalent (GGE) units for use in retail commercial sales (see endnote<sup>ii</sup>).

This proposal presents the kilogram as the unit of measurement to be used in commercial sales. (See Figure 1 [pg 7] for an example of how the unit measurement may appear on the dispenser, and see Figure 2 [pg 7] on how the street signs will display the unit price). The unit can be shown using the term "kilogram" or by use of its accepted abbreviation "kg," which is its prescribed symbol in NIST Special Publication 330 – "The International System of Units (SI)."<sup>4</sup>

Nothing in the proposal should be interpreted as prohibiting the use of a hydrogen GGE for information purposes to facilitate general comparisons with other fuels in advertisements and other literature. Consumers who are considering the lease or purchase of a hydrogen vehicle should be informed that they will be purchasing fuel by the kilogram and that they can make reliable value comparisons using that method of sale.

**The FSS recommends that in retail sales "HXX" be used to represent Hydrogen vehicle fuel and the capital "H" precede the "XX," which represents the service pressure of the hydrogen fuel offered for sale (expressed in the International System of Units (SI) unit megapascal [MPa]).**

## **Product Identity**

The FSS agreed to support the use of the capital letter "H" as the symbol for hydrogen instead of H<sub>2</sub> to simplify product identification of hydrogen vehicle fuel sold at the retail level.

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<sup>3</sup> Available at <http://www1.eere.energy.gov/vehiclesandfuels> on the Internet

<sup>4</sup> See NIST Special Publication 330 – 2008 "The International System of Units (SI)." Ambler Thompson, Editor.

### **Service Pressures shall be shown in the SI Unit Pascal (MPa)**

Knowing the service pressure of the dispenser is a critical factor for consumers as the storage tanks on their vehicle is designed to be filled at one of those pressures. In addition to needing this information for safety and vehicle filling purposes, participants at the March 2008 FSS meeting indicated that retailers may charge different prices depending on the delivery pressure at which the fuel is dispensed. Currently, some dispensers are marked with service pressures in units of bar<sup>5</sup> (e.g., 350 bar and 700 bar) or megapascals (MPa), which are the pressures available to service hydrogen vehicles. A few dispenser manufacturers use megapascal (MPa) in trade publications and in declaring dispenser delivery pressures. The FSS agreed that the service pressure at which the product is dispensed must be posted on the user's interface of all dispensers.

While the bar is accepted for use with SI, the metric system, the primary SI unit for pressure is the pascal (international symbol – Pa). Typical values encountered for dispenser of service pressures in pascals, bar and pounds are 35 MPa (350 bar) (approximately equivalent to 5 000 psi) and 70 MPa (700 bar) (approximately equivalent to 10 000 psi). The FSS agreed that in using the SI unit for pressure, the pascal would standardize industry practice and enable it to easily present this information in a consistent manner. It will also simplify the manner used to declare service pressures on dispensers, street signs, and in advertisements.

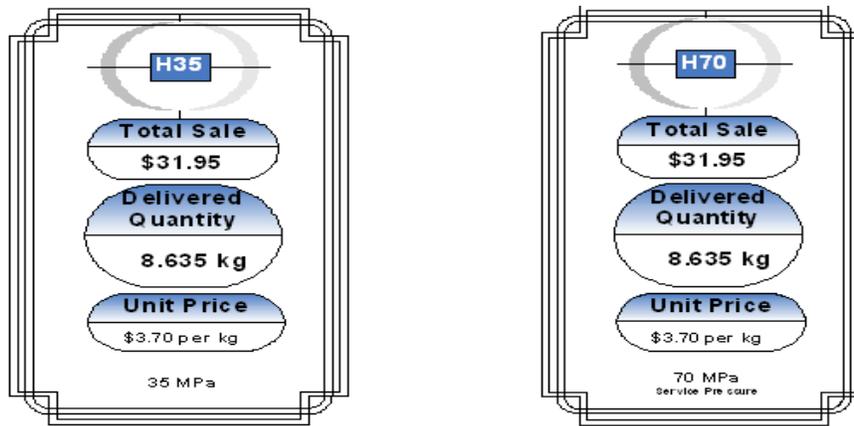
### **Unit Pricing in Whole Cents**

The FSS also agreed that the conditions for sale, when unit pricing is based on features, such as operation pressure, should be stated with the unit price in whole cents per kilogram on street signage to inform drivers of hydrogen vehicles of the service pressures available at the retailer's fueling facility. The proposal does not mandate street signs, but will require that when street signs are available they must display the unit price and service pressure of the dispensers. The requirement is only applicable when retailers voluntarily post or present the price of fuel in advertisements and on street signs.

The FSS agreed the traditional practice of using decimal fractions of a cent in unit pricing in advertisements, the unit price, or in the calculation of total prices should not be extended to sales of hydrogen fuel. Under the proposed method of sale, that practice is prohibited (e.g., \$3.499 per kg would not be permitted but \$3.49 per kg would be permitted).

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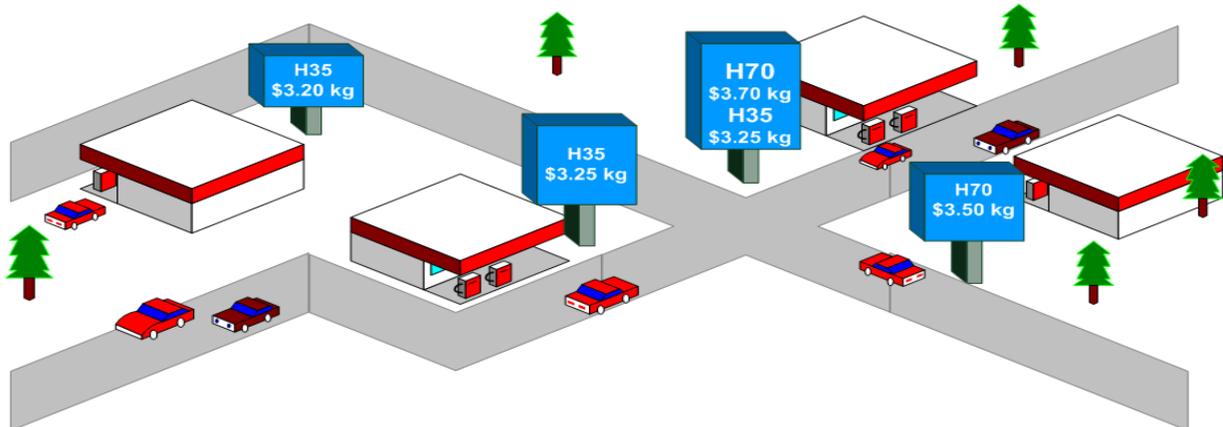
<sup>5</sup> A bar is an atmospheric pressure defined as 100 kilopascals. See NIST Special Publication 330 – 2008 “The International System of Units (SI).” Ambler Thompson, Editor.



**Figure 1.** Examples of the product identity, measurement unit, unit price, and service pressure on the user's interface of a hydrogen Fuel Dispenser

### A Competitive Marketplace

Figure 2 depicts how a fueling station in the marketplace might display required information. The purpose of the graphic is to illustrate that a uniform method of sale in a single unit of measurement and other requirements for posting of service delivery information will facilitate value comparison in a competitive marketplace and provide users with critical information. The graphics of the signage shows how posting the unit of measurement and service pressure provides drivers with information to permit them to make product and service pressure value comparisons between retailers.



**Figure 2.** The use of the uniform unit of measurement and posting of product identity, and service pressure to enable value comparison.

One alternative to the posting of service pressures (perhaps even unit prices) may be found in the growing prevalence of vehicle navigation systems and satellite information services. If drivers of hydrogen vehicles have access to real-time price and service pressure information through those systems, and use them to make their purchasing decisions, the current approach of using street signage may not continue in this marketplace.

**The FSS supports the following method of sale for petroleum:**

**Recommendation:** The FSS supports the proposal to be included in NIST Handbook 130: Section IV: Uniform Regulation of Method of Sale of Commodities. The FSS presented the following recommendation for consideration by the 2009 NCWM L&R Committee. This modified version includes a change to paragraph 2.XX.4.2 to include the units of megapascals.

**Section 2. Non-food Products** <sup>[Note 1, page 103]</sup>

**2.XX. Retail Sales. – Hydrogen Fuel (H).**

**2.XX.1. Definitions – Hydrogen Fuel (H).**

**2.XX.1.1. Hydrogen Fuel. – A fuel composed of the chemical hydrogen intended for consumption in an internal combustion engine or fuel cell.**

**The symbol for hydrogen vehicle fuel shall be the capital letter "H" (the word Hydrogen may also be used.)**

**2.XX.2. Method of Retail Sale and Dispenser Labeling. – All hydrogen fuel kept, offered, or exposed for sale and sold at retail shall be in terms of the kilogram.**

**2.XX.3. Retail Dispenser Labeling.**

**2.XX.3.1. A computing dispenser must display the unit price in whole cents on the basis of price per kilogram.**

**2.XX.3.2. The service pressure(s) of the dispenser must be conspicuously shown on the user interface in bar or the SI Unit of Pascal (Pa) (e.g., MPa).**

**2.XX.3.3. The product identity must be shown in a conspicuous location on the dispenser.**

**2.XX.3.4. National Fire Protection Association (NFPA) labeling requirements also apply.**

**2.XX.3.5. Hydrogen shall be labeled in accordance with 16 CFR 309 – FTC Labeling Alternative Fuels.**

**2.XX.4. Street Sign Prices and Advertisements.**

**2.XX.4.1. The unit price must be in terms of price per kilogram in whole cents (e.g., "\$3.49 per kg" not \$3.499 per kg).**

**2.XX.4.2. The sign or advertisement must include the service pressure(s) (expressed in megapascals) at which the dispenser(s) delivers hydrogen fuel (e.g., H35 or H70).**

### **Section III. Hydrogen Vehicle Fuel Quality Specification**

The FSS will continue to develop a model regulation to specify the quality requirements for hydrogen vehicle fuel for addition to the Uniform Fuels and Lubricants Regulation (UFLR) in NIST Handbook 130. The UFLR cites ASTM International and SAE International standards for gasoline, diesel, and other fuels. At least 11 states use that model regulation as a basis for their rules on fuel quality. As with other fuels, the regulations in Handbook 130 will reference standards from appropriate standards organization and utilize the test methods authorized and referenced by those standards. The proposed regulation will likely include standards developed by ASTM International, SAE International, and the International Organization for Standardization (ISO), or other American National Standards Institute (ANSI) accredited organization.

The State of California is at the forefront in establishing a fuel quality standard for Hydrogen to meet a legislative mandate.<sup>6</sup> At its first meeting in March 2008, the FSS participants reviewed the March 3, 2008 draft developed by the CDFA/DMS so that it could be used as a starting point in the development process for a national standard. This approach takes advantage of California's expertise, and the fact that it has been published for comment as part of that state's rulemaking process, meaning that it has received public review. The CDFA/DMS proposal provides an interim standard for hydrogen fuel.

Once ANSI has adopted a fuel standard, the CDFA/DMS is required by law to adopt that standard by reference. Since test procedures have not yet been finalized to measure the properties specified in the CDFA/DMS interim standard, that agency will adopt sampling and test procedures in regulation as they are developed. The agency will begin enforcement of its regulations and require compliance once sample and test procedures have been adopted by an accredited organization and its regulation are finalized. Several FSS participants reminded the group that the higher the quality of the fuel the higher its cost may be, so the approach taken in the United States must be practical and cost effective if the commercialization of hydrogen vehicle fuel is to be successful.

#### **Proposed Specification for Hydrogen Fuel**

The FSS identified several quality criteria where there was tentative agreement with their associated values and the ability to test to those values with current technology available today (see properties 6, 7, 8, 9, 12, 14, and 16 which are highlighted in green) in the proposed Table 1. Hydrogen Fuel Quality Specification.

The FSS did not agree on all of the properties contained in the DMS proposal because there was either not enough research data or test methods available to support a decision (see properties 1, 2, 3, 4, 5, 10, 11, 13, and 15 which are highlighted in yellow) in Table 1 below. These and perhaps other properties will receive further consideration by the FSS and may be added to the quality standard in the future when such action is supported by research.

FSS supports the proposed new definitions to be included in NIST Handbook 130 Section IV. Uniform Regulations Part G. Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulations Section 2. Standard Fuel Specifications to address gaseous hydrogen refueling applications.

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<sup>6</sup> See <http://www.cdfa.ca.gov/dms/hydrogenfuel/hydrogenfuel.html> for more information on the California Division of Measurement Standards Hydrogen Fuel Program. (Viewed 4/11/08)

**1. Specification for Hydrogen Fuel for Internal Combustion Engines and Fuel Cells**

**2. Definitions**

**1.XX. Fuel Cell. – an electrochemical energy conversion device in which fuel and an oxidant react to generate energy without consumption of its electrodes or electrolyte.**

**1.XX. Hydrogen Fuel. – a fuel composed of the chemical hydrogen intended for consumption in a surface vehicle with an internal combustion engine or fuel cell.**

**1.XX. Internal Combustion Engine. – a device used to generate power by converting chemical energy bound in the fuel into mechanical work to power a vehicle.**

Cite the appropriate reference for the hydrogen fuel quality standard below that was developed by the California Division of Measurement Standards in NIST Handbook 130 Section IV. Uniform Regulations Part G. Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulations Section 2. Standard Fuel Specifications as follows:

<b>Table 1. Hydrogen Fuel Quality Specification*</b>						
<b>Property</b>		<b>Value</b>	<b>Unit</b>	<b>Limit</b>	<b>Test Method(s)</b>	<b>Responsible Stds. Committee and Status of test method</b>
1	Ammonia	0.1	ppm v/v	Maximum	to be specified	WK 10196 under ASTM D03.14
2	Carbon Dioxide	2.0	ppm v/v	Maximum	to be specified	Wk 10196 and WK 4548 under ASTM D03.14
3	Carbon Monoxide	0.2	ppm v/v	Maximum	to be specified	WK 10196 under ASTM D03.14
4	Formaldehyde	0.01	ppm v/v	Maximum	to be specified	WK 10196 under ASTM D03.14
5	Formic Acid	0.2	ppm v/v	Maximum	ASTM D7550-09	WK 10196 under ASTM D03.14
6	Helium	300.0	ppm v/v	Maximum	to be specified	ASTM D03.14
7	Hydrogen Fuel Index	99.97	% <sup>(a)</sup>	Minimum	to be specified	
8	Nitrogen and Argon	100.0	ppm v/v	Maximum	to be specified	WK 4548 under ASTM D03.14
9	Oxygen	5.0	ppm v/v	Maximum	to be specified	WK 4548 under ASTM D03.14
10	Particulate Concentration	1.0	mg/kg	Maximum	to be specified	WK 9688 and WK 21611 under ASTM D03.14
11	Total Allowable Non-Hydrogen, Non-Helium, Non-particulate constituents	100.0	ppm v/v	Maximum	to be specified	
12	Total Non-Hydrogen Gases	300.0	ppm v/v <sup>(c)</sup>	Maximum	to be specified	
13	Total Halogenated Compounds	0.05	ppm v/v	Maximum	to be specified	WK 23815 under ASTM D03.14
14	Total Hydrocarbons	2.0	ppm v/v <sup>(d)</sup>	Maximum	to be specified	WK 22378 under ASTM D03.14
15	Total Sulfur Compounds	0.004	ppm v/v	Maximum	to be specified	WK 24073 under ASTM D03.14
16	Water	5.0	ppm v/v	Maximum	to be specified	WK 10196 and WK 4548 under ASTM D03.14
Footnotes to Table 1:						
a. Hydrogen fuel index is the value obtained with the value of total gases (%) subtracted from 100 %.						
b. Total Gases = Sum of all impurities listed on the table except particulates.						
c. Total Hydrocarbons may exceed 2 ppm v/v only due to the presence of methane, provided that the total gases do not exceed 300 ppm v/v.						
* The FTC's Fuel Rating Rule (16 CFR Part 309) see the requirements in "Labeling of Alternative Fuels" at <a href="http://www.ftc.gov/bcp/edu/pubs/business/autos/bus29.shtm">http://www.ftc.gov/bcp/edu/pubs/business/autos/bus29.shtm</a> requires dispensers to bear an declaration of minimum percent of hydrogen determined according to test methods described in "Standard Test Method for Analysis of Natural Gas by Gas Chromatography (ASTM D1946)						
Updated 1/20/2010						

The FSS will monitor national and international standard activities, research, and other programs to avoid duplication of effort and to ensure that its work provides a fuel specification for hydrogen vehicle fuel that serves the needs of the this emerging marketplace. Quality standards are currently under

development in SAE International (e.g., SAE J2719 “Hydrogen Specification Guideline for Fuel Cell Vehicles”) and in ASTM International (e.g., see [www.astm.org](http://www.astm.org) for a list of the work underway in its Committee D03.14 on Hydrogen and Fuel Cells and that organizations other committees).

Quality standards are under consideration around the world, including the European Union, Japan, and other countries. Also of interest are the efforts of Working Group 12 of ISO’s Technical Committee 197 on Hydrogen, which is very active in this area.<sup>7</sup> ISO’s website indicates that its fuel quality standard will be finalized within a few years.

When a quality property and numerical value (defining a maximum or minimum limit) is added to the specification, appropriate test methods must then be identified. As test methods are identified and adopted by the FSS, they will be added to Column 6 in Table 1.

Future work of the FSS may include the development of recommendations for field sampling equipment and handling procedures, along with suggestions about what type of test equipment is appropriate for establishing a hydrogen vehicle fuel quality laboratory.

**For Further Information or to Comment Contact:**

Please send comments and suggestions concerning the proposals presented in this document to Ms. Lisa Warfield or Mr. Ken Butcher, Technical Advisors to the USNWG Fuel Specifications Subcommittee, at [lisa.warfield@nist.gov](mailto:lisa.warfield@nist.gov) or (301) 975-3308 or [kbutcher@nist.gov](mailto:kbutcher@nist.gov) or at (301) 975-4859. Faxes may be sent to (301) 975-8091.

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[http://www.iso.org/iso/standards\\_development/technical\\_committees/list\\_of\\_iso\\_technical\\_committees/iso\\_technical\\_committee.htm?commid=54560](http://www.iso.org/iso/standards_development/technical_committees/list_of_iso_technical_committees/iso_technical_committee.htm?commid=54560). (Viewed 9/2/09)

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<sup>i</sup> **Additional Information on the Importance of a Method of Sale** – Establishing a uniform method of sale ensures marketplace integrity and increases consumer confidence while ensuring fair trade practice in a competitive marketplace. In past experience, the lack of a legal standard of sale has resulted in sellers establishing different methods of sale for the same product. This resulted in investments in weighing and measuring equipment and spending on packaging and marketing programs, only to find that the units of measurement used were not appropriate for the commodity. Once a new standard was established, existing measuring equipment, labeling, and sales literature had to be retrofitted or discarded. Establishing a method of sale early in the process informs the designers of weighing and measuring devices about how they are to design the device and the user interface. It also enables marketers to create sales and promotional programs for the product using a consistent unit of measurement throughout the system. Past experience with conflicting methods of sale has taught weights and measures and sellers many valuable lessons over the years. One of the most important lessons is that consumers are intelligent and willing to learn new methods of sale and readily accept products and services, if the information they receive from different sellers is informative, uniform, and accurate. Establishing a uniform method of sale will also inform automobile and fuel cell manufacturers about how they will need to educate consumers in sales literature and owners' manuals about the fuel and how it will be measured for dispensing into the vehicles and other refueling applications. Decisions are needed so that as marketing and promotional ideas are being considered and developed, the uniqueness of the fuel and dispensers can be addressed using a single unit of measurement.

<sup>ii</sup> **Additional Information on the Gasoline Gallon Equivalent** – A question at the FSS March 2008 meeting was whether the marketing of hydrogen vehicles against those that use fuels sold on the basis of a gallon would benefit from the establishment of a gasoline gallon equivalent (GGE). GGEs are based on energy content of fuels. GGE for hydrogen is mentioned in the media and government literature as 1 kg = 119,823 kilojoules (kJ) (113,571 BTU (lower heating value). GGE is used to compare the fuel in terms of price per gallon and to introduce hydrogen as a commercial vehicle fuel. This approach facilitates those comparisons as long as it is also understood that the energy content in a gallon of fuel varies widely with the fuel. When the GGE for Compressed Natural Gas (CNG) was developed as a legally defined value in the 1990s, one reason for its adoption was to allow consumers to compare the cost of competing fuels on street signs and on dispensers in a unit of measurement that was comparable among fuels such as gasoline. Thus, consumers could determine the potential savings when choosing a vehicle capable of using one type of fuel over another. In 1994, the GGE was set at 2.567 kg for CNG by NCWM using the lower heating value of gasoline, which was then given at 120,401.7 kJ (114,118.8 BTU). It should be noted that the adoption of the GGE for CNG was somewhat contentious. A proposal to add a diesel gallon equivalent (DGE) for CNG is expected to be on the NCWM's agenda in 2009.

It is difficult to make accurate comparisons between fuels because energy content varies by fuel, by region, and season for gasoline. Currently, the *Transportation Energy Data Book* lists the net energy of a gallon of gasoline at 121,753.4 kJ (115,400 BTU) and diesel as 135,785.7 kJ (128,700 BTU). Variations in energy content increase when gasoline is blended with Ethanol (E10 or E20) and E85 (15 % gasoline + 85 % ethanol) which contains only 89,679.76 kJ (85,000 BTUs) according to the National Ethanol Vehicle Coalition. Hydrogen fuel, which is expected to come into the marketplace as a commercial fuel within the next ten years, will be competing for customers who have far more fuel choices than are currently available. If a GGE is considered for hydrogen, the question that should be asked is "Would a GGE based on today's net energy content for hydrogen be a valid tool 10 years from now to compare it against gasoline, CNG, E85, diesel, and other fuels and the new electric cars expected from automobile manufacturers?"

Because of constant changes in energy policies and environmental concerns, new fuels and blends will continue to emerge in the marketplace. This constant state of change impacts the validity of GGEs. One question that must be raised if a GGE for hydrogen is proposed is, will these artificial comparison tools be periodically reviewed to ensure they provide the equitable means of ensuring reasonable and reliable comparisons between fuels.

**E-mail received from B.P. Global Fuels Technology, James Simnick**

From: Randy Jennings [Randy.Jennings@tn.gov]  
Sent: Tuesday, July 06, 2010 10:54 AM  
To: Williams, Juana; Warfield, Lisa; Butcher, Kenneth S.; Joe Benavides  
Subject: Hydrogen Specification

Please distribute to appropriate individuals.

>>> "Simnick, James J" <James.Simnick@bp.com> 7/6/2010 9:30 AM >>>  
Randy

BP appreciates the opportunity to comment on this NCWM proposal for hydrogen quality. I have reviewed the proposed hydrogen fuel quality specification by the NIST National Council of Weights and Measures. [http://ncwm.net/sites/default/files/meetings/annual/2010/10\\_Pub\\_16\\_LR.pdf](http://ncwm.net/sites/default/files/meetings/annual/2010/10_Pub_16_LR.pdf)

In my opinion, this proposal is both premature and the data insufficient for developing such a specification. I have cc'd several members of the DOE Freedom Car hydrogen program Delivery Technical team, of which I'm a member, for their possible input.

My reasons are as follows.

1. The proposal cites the need for hydrogen fuel quality specification for both fuel cells vehicles and internal combustion engines. Yet only one set of quality limits is proposed. The limits are totally unsupported for a ICE hydrogen engine, and in fact, also for a fuel cell vehicle (FCV).
2. For fuel cell vehicles, only prototype test vehicles refueling at controlled sites are using hydrogen today. There is no need at this time to promulgate such a specification until we have the supporting data to do so and there is a also a need to protect consumer FCV's. Neither of those items are in play today or in the near future.
3. The original limits for the SAE hydrogen fuel quality guideline (SAE J2719) were proposed as the lowest limits of detection for the analytical tests believed to detect the particular contaminant at that time. That is no way to set a specification limit. Limits should be based on publically available data on fuel cell vehicle durability and performance with various levels of hydrogen contaminants. Such data does not now exist, but will be in the future.
4. To develop a specification without fully vetted and approved consensus analytical test methods for key contaminants is a futile effort. Without agreed upon test methodology, no one can enforce nor defend themselves based on such a specification. ASTM D03.14 subcommittee is making great progress on these sampling techniques and test methods but they are not yet all approved and published.
5. The State of California developed such a specification when mandated by their state law. However this development was met with many problems for the reasons 1-4 as cited above. Relief was necessary from the specification by allowing hydrogen refueling sites in California petition for a waiver for test vehicle use of hydrogen for refueling.

In summary, BP believes that it is premature to develop such a specification for hydrogen until such time the data to support such a specification is available, necessary analytical test methods are published, and there is a need to protect consumer vehicles using hydrogen as fuel.

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**E-mail received from U.S. Fuel Cell Council, Robert Wichert**

From: RobertWichert [mailto:wichert@fuelcells.com]  
Sent: Friday, July 02, 2010 9:40 AM  
To: Joe Benavides  
Cc: Williams, Juana; William.Collins@UTCPower.com; Ruth Cox;  
brose@usfcc.com;  
william.chernicoff@dot.gov  
Subject: Method of Sale for Hydrogen

Dear Mr. Benavides:

As the Technical Director of the US Fuel Cell Council I wish to express my support for the Method of Sale for Hydrogen that will be before your committee shortly. The US Fuel Cell Council is the industry association for fuel cells and our members include the most active and successful fuel cell and hydrogen companies from all over the world. I know that our industry needs a trial code for hydrogen gas measuring devices and a corresponding method of sale in order to progress towards the large-scale deployment of hydrogen fueling stations necessary to meet our goals of increasing transportation efficiency and lowering greenhouse gas emissions. I hope that you will help us to achieve those goals by moving the Method of Sale for Hydrogen forward.

Thank you for your consideration and support.

Sincerely,

Robert Wichert, P.Eng. LEED AP  
Technical Director, US Fuel Cell Council

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**E-mail received from UTC Power, William Collins**

**From:** Collins, William P UTPWR [mailto:William.Collins@UTCPower.com]  
**Sent:** Friday, July 09, 2010 3:44 PM  
**To:** Williams, Juana  
**Subject:** NIST 44 & 130

Juana,

My comments and suggestions:

**232-3 V “Method of Sale for Hydrogen”.**

These proposed changes are actually proposed additions to NIST Handbook 130 “Uniform Regulations for Method of Sale of Commodities”. The additions include labeling and units of measure. The additions, “as proposed” are adequate. However, clarification of several points might be to the industry’s advantage. Specifically:

**2.XX.2 “The symbol for Hydrogen vehicle fuel shall be a capital letter “H”.”**

It is suggested that it would be better if DOC NIST, DOT NHTSA and SAE (Industry) were on the same page for labeling. SAE J2578-2009, Section 4.7, suggests labeling as “CHG” in white letters against a blue diamond background for compressed hydrogen gas. The document also suggests using “LH2” in white letters against a blue diamond background for liquid hydrogen. DOT NHTSA often adopts the SAE suggestions.

**2.XX.3.4. National Fire Protection Association (NFPA) labeling requirements also apply.**

It is suggested that only labeling per NFPA 704, “Standard System for the Identification of the Hazards of Materials for Emergency Response”, be referenced.

**Table 1. Hydrogen Fuel Quality Specification\* (version 19JAN2010)**

It is suggested that either SAE J2719 be referenced instead of this table or that the test methods being developed by ASTM to support J2719 be incorporated into the table.

**360-1 V “Code for Hydrogen Gas-Measuring Devices”.**

These proposed changes are actually proposed additions to NIST Handbook 44 “Hydrogen Gas-Measuring Devices Code”. The additions include labeling, accuracy and precision. The additions, “as proposed” are adequate. However, clarification of several points might be to the industry’s advantage. Specifically:

**S.1.3.3. Maximum Value of Quantity-Value Divisions. - The maximum value of the quantity-value division shall be not greater than 0.5 % of the minimum measured quantity.**

It is unclear as to what this means.

**S.1.4. Value of Smallest Unit. The value of the smallest unit of indicated delivery, and recorded delivery if the device is equipped to record, shall not exceed the equivalent of:**

**(a) 0.001 kg on devices with a maximum rated flow rate of 30 kg/min or less**

**(b) 0.01 kg on devices with a maximum rated flow of more that 30 kg/min**

It is assumed that this means that for devices flowing less than or equal to 30 kg/min, the total amount dispensed shall be measured to +/- 0.001 kg. It is also assumed that this means that for devices flowing more than 30 kg/min, the total amount dispensed shall be measured to +/- 0.01 kg. Is this correct?

**S.8. Minimum Measured Quantity. – The minimum measured quantity shall satisfy the conditions of use of the measuring system as follows:**

**a) Measuring systems having a maximum flow rate less than or equal to 4 kg/min shall have a minimum measured quantity not exceeding 0.5 kg.**

**b) Measuring systems having a maximum flow rate greater than 4 kg/min but not greater than 12 kg/min shall have a minimum measured quantity not exceeding 1.0 kg.**

It is assumed that this means that for devices flowing less than or equal to 4 kg/min, the total amount dispensed shall be measured to +/- 0.5 kg. It is also assumed that this means that for devices flowing more than 4 kg/min, the total amount dispensed shall be measured to +/- 1.0 kg. Is this correct? These values sound low. It is our understanding that cars will typically have enough fuel on board for an effective range of 300 to 400 miles. This would require from 5 to 10 kg of fuel. Based on these values, we would expect a requirement of +/- 1% of a full tank or ~0.075 kg.

William Collins  
UTC Power  
(860) 727-2559  
[william.collins@utcpower.com](mailto:william.collins@utcpower.com)

## Correspondence received from Van Putten-Blue Energy Observatories



Mr. Brett Saum, Chair Committee on Specifications and Tolerances (S&T)  
(BSaum@co.slo.ca.us<mailto:BSaum@co.slo.ca.us>).

Mr. Joe Benavides, Chair Committee on Laws and Regulations (L&R)  
(joe.benavides@texasagriculture.gov<mailto:joe.benavides@texasagriculture.gov>).

Re: USNWG hydrogen codes

July 10 2010

Dear Mr. Saum and Mr. Benavides:

I am writing you to express my support for the tentative hydrogen codes for inclusion in Handbook 44 outlining legal metrology requirements for hydrogen equipment used in vehicle refueling applications and Handbook 130 establishing a Method for Sale of hydrogen.

The v6.0 the USNWG's Hydrogen Gas-Measuring Devices-Tentative Code has been created under the excellent direction of Juana Williams with input from the regional weights and measures associations and comments from USNWG members.

Hydrogen is remarkably promising as a mobile energy carrier in view of its high energy content per unit weight, low-cost of storage in tanks and relative ease of making hydrogen out of possibly renewable energy sources.

Creating a consumer-oriented hydrogen economy forms one of the great challenges for the present century. The beauty of working on our future sustainable energy infrastructure is a potential pay-off in employment, reduction of energy costs and reliance on fossil fuels. It requires billing at custody transfer in the hydrogen pathway that, starting from a generating plant, may include hydrogen dispensing at high pressure to a tank wagon (i), a refueling station (ii), an automobile (iii) and, ultimately, in the low-pressure supply line to a combustion engine or fuel cell (iv).

The present tentative hydrogen code for (iii) is a first step for metering, certification and installation for refueling 350 or 700 bar hydrogen tanks in automobiles. If adopted by the NCWM, it will stimulate innovation on metering and field tests, generating valuable experimental data for feedback.

It has been drafted with an open mind towards further developments. For example, (iv) suggests on-board metering by existing low-pressure mass-flow metering technology with a proven record for safety and accuracy. In particular, we recently developed a new type of thermal mass-flow meter (US Pat. 7,246,519) which received approval for use in commerce by CTEP/CDFA (#5554-08). For hydrogen, it features a measurement uncertainty of 0.56% for pressures up to 16 bar. Regulatory approval at transfer point (iv) will be welcomed by the automobile industry, as I may infer from discussions at the recent NHA meeting at Long Beach earlier this year. Data generated in the field under the proposed trial code will be instrumental in developing legal metrology for the complete hydrogen pathway, complementing the present proposal for (iii).

I therefore endorse the proposed Handbook 44 trial code and Handbook 130 Method of Sale codes without reservation for gaseous hydrogen.

Sincerely yours,

Maurice HPM van Putten, Ph.D.  
CEO

Correspondence received from from California Fuel Cell Partnership



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Chrysler  
Daimler  
GM  
Honda  
Hyundai  
Nissan  
Toyota  
Volkswagen  
Automotive Fuel Cell Cooperation  
UTC Power  
Chevron  
Shell Hydrogen  
Cal/EPA Air Resources Board  
California Energy Commission  
National Automotive Center  
South Coast AQMD  
U.S. Department of Energy  
U.S. Department of Transportation  
U.S. Environmental Protection Agency  
AC Transit  
Air Products  
CA Dept of Food and Agriculture  
ITS-UC Davis  
Linde North America, Inc.  
NFCRC-UC Irvine  
NREL  
Powertech Labs  
Praxair  
Proton Energy Systems, Inc.  
Santa Clara VTA  
SunLine Transit Agency

June 25, 2010

Brett Saum  
Joe Benavides  
National Conference on Weights and Measures  
1135 M Street, Suite 110,  
Lincoln, Nebraska 68508

**RE: Support for agenda items 360-1 and 232-3: Tentative Code for Hydrogen Gas-Measuring Devices and Method of Sale for Hydrogen**

Dear Mr. Saum and Mr. Benavides,

The California Fuel Cell Partnership is a private-public partnership of auto manufacturers, energy companies, fuel cell companies, government, academia, and transit agencies. We actively collaborate to support fuel cell vehicle commercialization and help achieve California's goals for clean air, reduced greenhouse gases, and reduced petroleum use.

We recognize that one of the barriers inhibiting commercialization is the current inability to sell hydrogen as a retail transportation fuel. With this in mind, we would like to support the language proposed by the U.S. National Work Group for the development of commercial hydrogen measurement standards presented in agenda items 360-1 and 232-3 at the NCWM. We believe that the adoption of this language will create the appropriate starting point for developing commercial hydrogen fueling stations nationally.

The Tentative Code for Hydrogen Gas-Measuring Devices and Method of Sale for Hydrogen were developed with the best available information provided by industry experts, mostly members of the California Fuel Cell Partnership, and will provide a foundation for the commercial rollout of hydrogen vehicles. By adopting this language the United States can make significant progress toward expanding infrastructure and enabling hydrogen as a transportation fuel.

Sincerely,

Catherine Dunwoody  
Executive Director

The California Fuel Cell Partnership is a collaboration in which several companies and government entities are independent participants. It is not a joint venture, legal partnership or unincorporated association.

**Correspondence received from Daimler AG**

**DAIMLER**

Dr. Christian Mohrdieck  
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Germany  
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✉ christian.mohrdieck@daimler.com

Brett Saum and Joe Benavides  
National Conference on Weights and Measures  
1135 M Street, Suite 110,  
Lincoln, Nebraska 68508

July 8th, 2010

**RE: Supporting agenda items 360-1 and 232-3 at the National Conference on Weights and Measures**

Dear Mr. Saum and Mr. Benavides,

Daimler is a leader in the development and deployment of fuel cell vehicles, having investigated this technology since the public presentation of our first fuel cell vehicle in 1994. Over this period of time, we have conducted extensive on-road trials of fuel cell powered cars, vans and buses, with over 4.5 million kilometers driven. Daimler continues to be firmly committed to fuel cell technology, as demonstrated by the launch of the first series-produced fuel cell vehicle, the Mercedes-Benz B-Class F-CELL, in Europe and California later this year.

Codes and Standards development plays a crucial role in the commercialization of fuel cell vehicles. Specifically, one barrier to overcome is the current inability to sell hydrogen as a retail transportation fuel. We recognize that the efforts of the U.S. National Work Group to develop commercial hydrogen measurement standards are an essential step forward. Hence, Daimler would like to support the items 360-1 and 232-3 presented on the agenda at the National Conference on Weights and Measures. The adoption of the language for the *Tentative Code for Hydrogen Gas-Measuring Devices* and the *Method of Sale and Engine Fuel Quality Requirements for Hydrogen* will greatly facilitate the build-up of a much needed retail hydrogen infrastructure.

A retail hydrogen station network is essential to ensure the commercial success of Daimler's future fuel cell vehicles. However, such a network will only become viable with the requisite Codes and Standards in place.

Thank you for your continued efforts to make this a reality.

Sincerely  
Daimler AG



Dr. Christian Mohrdieck  
Director  
Fuel Cell & Battery Drive Development



Arwed Niestroj  
Senior Manager  
Fuel Cell & Battery Drive Development