U.S. National Work Group (USNWG)
for the
Development of Commercial Hydrogen Measurement Standards

April 28-30, 2009
California Fuel Cell Partnership (CaFCP)
3300 Industrial Blvd.
West Sacramento, CA 95691

Device Standards Subcommittee (DSS)
and
Fuel Specifications Subcommittee (FSS)

DRAFT MEETING SUMMARIES

The meetings of the USNWG Subcommittees were sponsored by the U.S. Department of Energy and U.S. Department of Commerce's National Institute of Standards and Technology.

The USNWG wishes to express its sincerest thanks to the California Fuel Cell Partnership for hosting the April 2009 meetings.

Purpose: The U.S. National Work Group (USNWG) Subcommittees met to continue their work to promote the establishment of a uniform and comprehensive set of (1) equipment design, accuracy, installation, and use, and method of sale requirements, (2) quality standards for hydrogen fuel, and (3) test procedures for fuel quality and equipment performance when used in hydrogen measurements for vehicle and other refueling applications.

AGENDA ITEMS

Attachments List		
Appendix	**Related Agenda Item(s)**	
A	(2)(a)* and **	Summary of the February 2009 USNWG Meeting
B	(3)(a)*	Examination Procedure Outline 29 (Draft Dec 2008)
C	(3)(a)(ii)*	Pros and Cons of the Performance Test Methods
D	(3)(a)(ii)*	Powertech Coriolis Meter Test Data
E	(3)(b)*	Draft 4.0 of NIST Handbook 44 Gas Measuring Devices Code
F	(3)(b)(i)*	Comparison of MMQ Requirements in Draft H2 Code and OIML R 139
G	(3)(b)(ii)*	Wholesale Delivery Gaps
H	(3)**	Draft 2.3 of NIST Handbook 130 Uniform Laws and Regulations, Engine Fuel Quality
I	(3)(b)(i)*	Comparison of the MMQ to Price per Gallon and the Test Standard and Dispenser Indication Resolution (29APR2009)-Cohen (APCI)
J	(1)	Attendee List
*Device Standards Subcommittee (DSS)		
**Fuel Specifications Subcommittee (FSS)		

Glossary of Acronyms			
ASTM	American Society of Testing and Materials International	MPa	megapascal
CaFCP	California Fuel Cell Partnership	NGV	Natural Gas Vehicle
CDFA DMS	California Department of Food and Agriculture, Division of Measurement Standards	NHA	National Hydrogen Association
CSA	Canadian Standards Association, Incorporated	NIST	National Institute of Standards and Technology
DSS	Device Standards Subcommittee	NTP	Normal Temperature and Pressure
EPO 29	Draft Hydrogen Gas Retail Motor-Fuel Dispenser Examination Procedure Outline (EPO) 29	OEM	Original Equipment Manufacturer
FSS	Fuel Specifications Subcommittee	OIML	International Organization of Legal Metrology
HB 44	NIST Handbook 44 Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices (2009)	OIML R 139	Recommendation for Compressed gaseous fuel measuring systems for vehicles
HB 130	NIST Handbook 130 Uniform Laws and Regulations in the Area of Legal Metrology and Engine Fuel Quality (2009)	RMFD	Retail Motor-Fuel Dispenser
HGV	Hydrogen Gas Vehicle	SAE	Society of Automotive Engineers
ISO	International Organization for Standardization	SI	International System of Units
MMQ	Minimum Measured Quantity	USNWG	U.S. National Work Group
MOS	Method of Sale		
This table is meant to assist the reader in the identification of acronyms used in this summary and does not imply that these terms are used solely to identify these organizations or technical topics.			

DEVICE STANDARDS SUBCOMMITTEE (DSS) MEETING

Tuesday, April 28-29, 2009, 8:30 a.m. – 5:00 p.m. (PDT)
California Fuel Cell Partnership
West Sacramento, CA
Chair – Kristin Macey (CDFA DMS)
Technical Advisor – Juana Williams (NIST WMD)

(1) Welcome and Introductions

The DSS participants were welcomed inperson and on audio conference, the meeting was called to order, and its purpose reviewed. The collaborative work by the meeting's sponsors was recognized. Participants were briefed on the facilities available at the California Fuel Cell Partnership, the schedule of events, meeting procedures, and materials. Participants provided their name, affiliation, and stated their specific area of interest in the work to develop hydrogen measurement standards.

(2) Administrative Business

The DSS addressed the following items:

(a) Approve the Summary of the February 2009 USNWG Meeting (See Appendix A)

The DSS approved the February 2009 meeting summary as written.

(3) Development of Device Standards and Test Procedures for Commercial Hydrogen Measurement

During the February 2009 teleconference, the USNWG agreed to develop a tentative action plan for any outstanding issues either before or during the course of this week's April 2009 meeting. An action plan was recommended to ensure that there are no gaps in the final code that might delay its acceptance in the weights and measures standards development process in fall 2009.

The Technical Advisor identified eight areas of the draft code as requiring additional discussion and possible resolution by the DSS because they might be perceived as gaps in the weights and measures hydrogen infrastructure. The DSS agreed to achieve this goal by prioritizing and identifying a course of preliminary action necessary in the areas of: (1) Minimum measured quantity (MMQ), (2) Wholesale Applications, (3) Stationary versus Mobile Applications, (4) Questionable Carryover Codes, (5) SAE Fill Protocol Guidelines, (6) Test data and procedures, (7) Key player outreach, and (8) Tolerance tables ((8) added to the list at the April 2009 meeting). The issues listed below in paragraphs (a) and (b) represent the eight areas identified by the USNWG.

The focus of the April meeting was to eliminate any gaps in Draft 4.0 of the HB 44 Hydrogen Gas-Measuring Devices Code, to avoid delays in the code's review and its subsequent approval and adoption during the 2010 cycle for the weights and measures standards development process. The preliminary outcome of DSS discussions are as follows:

- Provide real world examples of stationary and mobile refueling systems to clarify that the code applies to both applications (see Agenda Item (3)(b)(iii))
- Schedule a June 17, 2009 (3:00 p.m. to 5:00 p.m. [EST]) Tele/Webconference meeting to ensure the draft code fully addresses both wholesale and retail applications (see Agenda Item (3)(b)(ii))
- Contact other national and international legal metrology organizations, laboratories, etc. most likely to have sufficient test data that demonstrates the (see Agenda Item (3)(a)(ii)):
    - availability of a test standard(s) that meets HB 44 requirements in the Fundamental Considerations for use to evaluate a hydrogen refueling system's performance

    - ability of hydrogen refueling systems to attain the proposed tolerances in the draft code

- Modify paragraph S.1.3.3. to specify a maximum value of the quantity-value division of 0.001 kg rather than require its value not exceed a fixed percentage of the minimum measured quantity (see Agenda Item (3)(b)(i)

For more information on these actions by the DSS, see the discussions below.

(a) Test Procedures

On multiple occasions the DSS has requested input from the weights and measures and hydrogen communities on test procedures and equipment. The test method and the test equipment must meet the allowable errors and uncertainties for a test standard (see HB 44 Appendix A Fundamental Considerations 3.2. Tolerances for Standards (page A-2)). The USNWG is in the early stages of establishing guidelines for test methods so that each test method does not contribute significant error to the test results. This concept is important to ensure the test equipment does not use up the entire HB 44 tolerance allowed the dispenser. The 1.5% Acceptance and 2.0% Maintenance Tolerances specified in the draft code are consistent with those for similar applications in the Mass Flow Meters Code and corresponding OIML requirements (R139).

Test procedures used by field officials and laboratory type evaluation criteria are based on the requirements in HB 44 General and specific device code sections. Diane Lee (NIST) is still seeking input on the draft outline of the examination procedure (see Appendix B) for field official's and industry's use that was presented to the DSS in December 2008.

Ms. Lee advised the DSS that the NIST uncertainty analysis of the three test methods recognized in the draft code include the z factor for hydrogen in the analysis equations. This compressibility (z) factor is used in recognition of the actual behavior of hydrogen gas at these low temperatures and high pressures rather than that of an ideal gas. The uncertainty analysis for gravimetric and volumetric test methods is nearing completion. The next step will be to determine the uncertainties associated with the master meter test method. This information will be important in the selection of an appropriate test method, given the combined error and uncertainty of the test standard must be less than one-third of the applicable performance tolerance when the standard is used without correction.

The flow-rate turndown ratio typically seen in existing devices is 100:1, which makes a single tank size and test standard (reference scale) that works to verify the equipment's accuracy across its entire flow range difficult to find. It appears that multiple tank sizes and reference scales (test standards) with suitable resolution and capacity will be necessary. The test tank standard that will be referenced in test procedures will follow those guidelines developed by ISO, SAE, and/or NGV.

An alternate "Measured Decant" test method was suggested by Joe Cohen (APCI), in which, the quantity of fuel discharged from the test tank is measured through a meter at low pressure. This method would require the establishment of an appropriate start and end pressure, but would eliminate concerns about the affects of high pressure on the measurement verification process. The worst case conditions would be simulated by deliveries into a small tank at a slow flow rate on a hot day and a delivery at a fast flow rate into a large tank on a cold day. Any attempt to simulate intermediate test draft sizes, flow rates, or pressures or to activate the low flow cut-off by throttling down the flow rate were deemed unsafe and could cause a heat build-up in the test tank. In the past, the affects of environmental temperature has been known to be a factor contributing to measurement error in the meter. Meter manufacturers have overcome this problem to some degree through modifications to the meter housing. In principal these adjustments might be carried over in the design and set up of the test standard.

(i) SAE Test Tank Standard and Fill Protocol
The DSS agreed that collaboration with SAE on guidelines for a test unit would be beneficial and it would consider input from SAE as it works on specifications for the test standard's design and develops weights and measures test procedures. The DSS awaits input from SAE to maximize the possibility for use of a single test unit that is capable of verifying the systems' compliance with SAE standards and legal metrology requirements. This work overlaps into the CSA HGV 4.3, Hydrogen Test Device Working Group for Temperature Compensation Devices for Hydrogen Dispensing Systems project. The DSS agreed that there are benefits to developing a single test standard that allows for an evaluation of hydrogen refueling equipment to both safety and accuracy standards.

The SAE guidelines are meant to determine that fills at 35 MPa and 70 MPa meet pressure ratings and do not exceed temperature limits. The fill protocol is meant to demonstrate the systems' safe operation under worst case conditions such as a slow flow on a hot day. An example of an extreme condition where HB 44 requires a specific performance test might be the "product depletion test," which is an examination of the performance of a vehicle tank meter system's air eliminator when product is depleted from one storage tank and then switches over to a second storage tank. This ensures that product, not air, is measured by the meter. SAE has indicated that it is interested in testing only one design of test standard that will include multiple tanks (at least two) and the later phase of its work will include operator training.

Weights and measures requirements and test procedures are not meant to require a demonstration of accurate delivery at extreme operating conditions that are outside of the operating range designated by the hydrogen measuring system's manufacturer. For example, a system operating below the manufacturer's lowest flow rate delivery for more than a short period of time would stop operating because of the draft code's low-flow-rate cut-off requirement.

One objective in the establishment of legal metrology requirements is to test the equipment's performance across the entire range of flow rates under *normal* use in real-world conditions. It should be noted that hydrogen dispensing system's manufacturers indicate the dispensers are designed for the same fill time regardless of the pressure or size of the vehicle's storage tank. Drivers are expected to fill-up based on driving distances between hydrogen service stations and the vehicle's fuel tank storage capacity, similar to fueling practices with gasoline powered vehicles. It is clear that simulating these real-world scenarios in the test criteria will impact the selection of test vessels/receptacles of appropriate sizes and numbers. It should also be noted that the SAE guidelines may include prescriptive requirements for dispensing time and flow rates but are not prescriptive for the mass capacity(s) of the test tank(s).

(ii) Test Data
In response to the DSS's request for performance data, the results of tests performed by Powertech Labs, Inc. were made available by Micro Motion Inc. (See Appendix D). Test data was requested to demonstrate the performance tolerances in the draft code are reasonable. The data was provided in a PowerPoint presentation that summarizes the performance of two coriolis mass flow meters. The performance data represents fast fill testing of two separate meters used to deliver gaseous hydrogen. The data demonstrates the performance of meter A with an average error of – 4.06% and meter B with an average error of – 0.99%, where meter B was within the proposed tolerances specified in the draft code. Test drafts ranged from 50 g to 15 kg. Several factors that might need to be included in the final test procedures are: (1) simulations of vehicle communications to the dispenser and (2) conditioning of the product or a waiting period for the product to settle or reach equilibrium since the external temperature of the test tank can change 5 to 15 ºC immediately after fill. One suggestion was to require a waiting period of five to ten minutes for each 3 to 5 ºC temperature change to allow the tank temperature to reach equilibrium. Manufacturers did not believe the duration of the waiting period would need to extend beyond 30 minutes. Test procedures that require longer waiting periods will require more resources from the weights and measures jurisdiction and down time for service station equipment under test.

During the DSS discussions, several manufacturers indicated that meter B is not available for purchase. These manufacturers also noted that mass flow meters currently available are designed for use in lower pressure applications where the thickness of a meter's walls is not a concern. However, in the high pressure environment in hydrogen refueling systems the piping and other surfaces must withstand pressure bursts of 50:1 and do so over the life of the meter. Other factors identified that might affect measurement accuracy were the effects of transient flow rates and the capability of input devices/components in the system to provide and transmit data for computing the quantity of a delivery. Officials questioned whether or not these systems have the capability for adjusting temperature sensors, transmitters, etc. to bring the mass flow meter into tolerance. These features, when metrological in nature, may also need some form of approved security. HB 44 Mass Flow Meters Code Section 3.37 permits conversion of mass to volume indications. In this instance, product density is a critical factor. However, for hydrogen the conversion process could have large inherent errors if factors that are significant contributors to measurement error are not addressed.

In an effort to generate more conclusive data on the equipment's performance to the proposed tolerances, the DSS agreed that Dan Reiswig (DMS) and Juana Williams (NIST) should contact other national and international legal metrology organizations, laboratories, etc. most likely to have sufficient test data that demonstrates the:

- availability of test standards(s) that meet HB 44 requirements in the Fundamental Considerations for use to evaluate a hydrogen refueling system's performance and

- ability of hydrogen refueling systems to attain the proposed tolerances in the draft code

(b) Draft Code

The DSS discussed Draft Version 4.0 of the HB 44 Hydrogen Gas-Measuring Devices Code (See Appendix E). This latest version of the draft code is the result of work by the DSS at its February 2009 meeting. The next step after the DSS finishes the development of the code is to request the final draft be approved and adopted as a tentative code at the national level in July 2010. There are no restrictions on how long a code must remain in a tentative status before it becomes permanent and enforceable.

The DSS continues to target fall 2009 for submitting a final draft of the device and fuel quality code for national adoption. The DSS will work to have the code ready by mid August 2009 so that it can be distributed to all four fall 2009 meetings of the regional weights and measures association and technical sector for measuring devices which are the starting point of the weights and measures standards development process for 2010.

Although the DSS identified several applications that will need to be addressed such as wholesale deliveries. There is one other methodology currently in operation where deliveries are not made through a meter, but are based on the pressure-volume-temperature (PVT) differential between the dispenser and receiving vessel/tank. This application would still be considered commercial and under the jurisdiction of the weights and measures authority. An analogy of why this is still a commercial application might be found if we examine sales based on the indications of indirect mass meter flow meters where mass is inferred from a measured volume or those of liquefied petroleum gas where there is no meter but the tank itself becomes the measuring device and the basis for the charge. These applications are considered commercial because measurements (predetermined, calculated etc.) are the basis for the sales transaction. During the April 2009 meeting the DSS modified only one draft code requirement. Paragraph S.1.3.3. Maximum Value of Quantity-Value Division was modified to specify the maximum quantity division value for retail hydrogen dispensing equipment as described below in DSS Agenda Item (3)(b)(i).

(i) Minimum Measured Quantity (MMQ)

The DSS examined whether or not requirements in Draft 4.0 of the Hydrogen Gas-Measuring Devices Code adequately define how to establish the system's MMQ so that its value does not conflict with other requirements in the draft code and corresponding national and international requirements. Draft 4.0 specifies the maximum value for "d" based on a percentage of the MMQ and also sets limits for the maximum MMQ based on the system's flow rate. The DSS assessed the need to further clarify the relationship of the MMQ in these specifications and if there is a need to develop new MMQ criteria to address other measurements, tolerances, and metrologically significant parameters of the measuring system.

The April 2009 DSS discussions documented below focus on: (1) the ability to verify the system's performance for deliveries at or near the MMQ based on test standard guidelines in the HB 44 Fundamental Considerations; (2) the proposed relationship established in paragraph S.1.3.3. Maximum Value of Quantity-Value Division which sets a maximum allowable value for "d " that is not greater than 0.5% of the MMQ; (3) the hydrogen system's ability to compute dollar amounts in a similar manner as gasoline dispensing systems, when "d" conforms to paragraph S.1.3.3 and the MMQ is limited by paragraph S.8 Minimum Measured Quantity; and (4) the compatibility of MMQ and other related requirements in Draft 4.0 with corresponding requirements specified in current HB 44 Mass Flow Meters Code and OIML R 139.

(1) Verification of MMQ

Draft Hydrogen Gas Retail Motor-Fuel Dispenser EPO 29 prescribes formulas for calculating the minimum test draft size. The EPO includes guidelines for the readability of the reference scale (gravimetric test method), and, where necessary, corrections using either error weights or expanded resolution of the reference scale to keep test procedures within the allowable percentage error (to include the digital rounding error of the scale). Draft EPO 29 recommends tests of the systems performance at deliveries of 1/3, 2/3, and full tank capacity. These test drafts were incorporated into Draft EPO 29 test procedures because these quantities represent the typical practices/patterns of motorist refueling their vehicles. Based on the smallest passenger vehicle tank capacity of 1 kg, the minimum test draft size would be a delivery of 333 grams, if Draft EPO 29 is followed. A test tank with a 1 kg- to 1.5 kg-capacity would be necessary for a test of the system's performance for the maximum allowable MMQ of 1.0 kg that is permitted in paragraph S.8 Minimum Measured Quantity. It should be noted that HB 44 requirements are the basis for the inspection and test procedures in the EPO.

Given a 200 gram-capacity of the test tank currently available and a performance tolerance of 1.5% for the system, the guidelines in HB 44 Fundamental Considerations require that the test standard error and uncertainty must be less than one-third of 1.5 % (± 3 gram allowable error). However, the test standard would not have sufficient resolution based on the formulas in Draft EPO 29 which specifies the reference scale division be less than or equal to the smallest test load multiplied by the tolerance for the device under test multiplied by one-tenth (200 g x 0.015 x .1 = 0.3 g or 0.0003 kg). Applying these principles avoids rounding errors, which can be cumulative in the weighing process. In this instance it may also be difficult to use error weights to correct for errors in the scale.

(2) Maximum Allowable Value for "d"

Given the maximum allowable MMQ of either 0.5 kg (for a flow rate less than or equal to 4 kg/min) or 1.0 kg (for a flow rate greater than 4 kg/min but less than 12 kg/min) specified in draft code paragraph S.8, the value of "d" cannot exceed 0.5 % of those MMQ values. The DSS agreed that if the relationship is true then mathematically the value of “d” could be as high as 0.02 kg in vehicle refueling applications, based on current manufacturers’ practices for establishing an MMQ equivalent to the flow rate.

The Mass Flow Meters Code specifies in paragraph S.1.3.3. Maximum Value of Quantity-Value Divisions that the maximum value of “d” shall be based on a percentage (0.2 %) of the MMQ in liquid applications. That code also specifies the maximum value of “d” in mass units (i.e. 0.001 kg) for gaseous vehicle refueling applications, where the value of "d" has no relationship to the MMQ for compressed gas applications. In current Draft 4.0 paragraph S.1.3.3. Maximum Value of Quantity-Value Divisions the value of "d" shall not be greater than 0.5 % of the MMQ. There is no similarity in the value of "d" for compressed gases in these two codes even though the applications are similar.

(3) Computing Dollar Amounts

The DSS made several calculations based on the current allowable ratio for the relationship of the MMQ to maximum size of the quantity-value indication specified in the draft code. The design of the maximum division value for use in gaseous hydrogen deliveries should be comparable to the division value in use for gasoline and CNG sales. The maximum division value should allow computation of money values to one cent values. This would eliminate rounding issues and allow sales at whole dollar amounts for unit prices up to at least $10.00/kg rather than limiting the computing capability of the hydrogen dispensing system's indications. A continuous indication (from zero to the final quantity) where the value of "d" is indicated in grams or 0.001 kg (i.e., three decimal places) is necessary. The maximum change in the quantity increment that can be displayed cannot exceed 0.001 kg.

The DSS also considered the selection requirements in HB 44 General Code paragraph G-UR 1.3 Liquid-Measuring Devices, which specify that deliveries shall be no less than 100 divisions. For a system with a "d" of 0.01 kg a minimum delivery would be 1 kg. A 1 kg delivery is too large to represent the sale of a motorist topping off their tank or a motorcyclist filling up.

Liquid Measuring Devices Code paragraph S.1.6.6. Agreement Between Indications requires that auxiliary devices print or replay the quantity value that is derived or computed based on data from the retail motor-fuel dispenser. That quantity value can differ between the dispenser and an auxiliary device so long as the total sale money values are equal and meet the formula (quantity x unit price = total sale to the closet cent)

Joe Cohen (APCI) prepared an excel spreadsheet projecting the ratio of the MMQ to the indicated quantity value, price per kg, and maximum allowable meter/system error to arrive at a concept for deriving the value of the MMQ (see Appendix I).

To determine the plausibility of conducting performance tests to within acceptable uncertainty and error limits, the DSS calculated several possible hydrogen sales. The transaction information was based on the outcome of sales calculated at the smallest displayed value for sales at both $0.01 and $0.10. When the quantity that can be displayed by the dispenser was greater than 0.001 kg this results in sales calculated to impossible values. This presents a problem when customers buy fuel based on dollar amounts.

The DSS agreed to modify paragraph S.1.3.3. to specify a value for "d" of 0.001. kg to be consistent with the corresponding "d" requirements for similar application in the Mass Flow Meters Code and to eliminate the possibility of having rounding issues and calculations of impossible values.

April 2009 DSS Modifications to Draft 4.0 of the NIST Handbook 44 Hydrogen Gas Measuring Devices Code		
Change to Requirement: Modified text in paragraph S.1.3.3.	Requirement Title: Maximum Value of Quantity-Value Divisions	Reason for Change: For consistency with the corresponding "d" requirements for similar application in the mass flow meters code and to eliminate the possibility of having rounding issues and calculations of impossible values
S.1.3.3. Maximum Value of Quantity-Value Divisions. - **For dispensers of compressed hydrogen used to refuel vehicles,** ~~T~~**t**he maximum value of the ~~quantity-value~~ **mass** division shall ~~be~~ not ~~greater than 0.5 % of the minimum measured quantity~~ **exceed 0.001 kg**.		

(4) Compatibility of Related National and International MMQ Requirements"d"

The April 2009 DSS modifications to paragraph S.1.3.3. was an attempt to align the draft code and HB 44 Mass Flow Meters Code requirements that prescribe limits on the value of "d" for gaseous applications. Draft 4.0 paragraph S.1.3.3. Maximum Value of Quantity-Value Divisions the value of "d" shall not be greater than 0.5 % of the MMQ.

The HB 44 Mass Flow Meters Code paragraph S.1.3.3. specifies a maximum value of the quantity-value division for liquid applications shall not be greater than 0.2 % of the MMQ and shall not be greater than 0.001 kg for mass division in compressed natural gas applications.

MMQ
The MMQ requirements in both codes are consistent with the NCWM's original intent to provide a mechanism for determining if a device is suitable for use in a given application. Typically, mass flow meter manufacturers have used the same quantity value declared as the meter's minimum flow rate to establish a value for the MMQ.

The limits for the maximum value for the MMQ are specified in Draft 4.0 paragraph S.8. Minimum Measured Quantity and are based on the system's flow rate. Flow ranges that are appropriate for passenger vehicles and motorcycles typically have maximum flow rates not above 4 kg/min and for bus refueling maximum flow rates are not above 12-15 kg/min. The minimum flow rate observed in a 35 MPa rated system is 0.36 kg/min (6 g/sec) and in a70 MPa rated system is 1.68 kg/min (28 g/sec). The ratio of the maximum to minimum flow rates for these systems are 20:1 but can be as high as 100:1 with the goal of filling a vehicle's fuel tank in 4 minutes. Draft 4.0 paragraph S.8 Minimum Measured Quantity states that the MMQ shall not exceed the 0.5 kg for systems with a flow rate less than or equal to 4 kg/min and the MMQ shall not exceed the 1.0 kg for systems with flow rates greater than 4 kg/min but not greater than 12 kg/min.

A minimum of two test drafts are required for an official test (see paragraph N.3. Test Drafts). The first draft should be a delivery at the MMQ and a second draft at either ten times the MMQ or 1 kg, whichever is greater.

The DSS also compared MMQ requirements in the draft code to those in corresponding OIML R 139 model regulation (See Appendix F) as part of the its discussions about the readiness of the draft code. The DSS did not elect to expand the MMQ requirements to include separate tolerances for errors and prescribe special test conditions relative to the MMQ as prescribed in R 139.

(ii) Wholesale Applications
The DSS discussed the need to develop requirements to address wholesale applications where a delivery is not made to the end user. Several dispenser manufacturers indicated there is a need to ensure that existing draft code requirements are not so prescriptive that most wholesale applications would have difficulty complying.

The DSS reviewed a list of specific paragraphs (See Appendix G) identified in the draft code by Bob Boyd (Linde NA, Inc.) and Joe Cohen (APCI) to determine if these sections adequately address commercial wholesale applications or create trade barriers. A "wholesale device" is defined in HB 44 as any device other than a measuring device primarily used to measure product for the purpose of sale to the end user. In many cases, wholesale devices are used to meter large deliveries into tank trucks, ships, and other large vessels. Even so wholesale applications, like retail, are regulated by the weights and measures authority. The current draft code would be the only code available to apply to wholesale devices used in hydrogen gas deliveries although the USNWG agreed there was a greater urgency for developing requirements for retail applications.

DMS noted it does not have any retail sales in the state of California that are based on a metered delivery. However, it does permit sales based on a flat fee in the interim since there is no adopted code, test procedures, or type approval criteria in place for hydrogen measuring devices.

Sales of large quantities of hydrogen gas in prepackaged containers (tubes or cylinders) will need to be addressed, possibly in HB 130 using language similar to that in the Uniform Regulations Part B Regulation of the Method of Sale of Commodities, Section 2 Non-food Products paragraph 2.16 Compressed or Liquefied Gases in Refillable Cylinders (see page 123 [2009 Edition]). Currently, HB 130 addresses the method of sale for small quantities of bottled gases such as oxygen, helium to include hydrogen. The HB 130 Method of Sale requirements are the basis for a separate inspection procedure for verifying the accuracy of quantity and proper labeling of the gas cylinder.

Dispenser manufacturers indicated that the predominant methodology for hydrogen measurement in wholesale deliveries is the PVT method. In the event that there is a dispute over a wholesale PVT transaction, even when a contract is in place, the weights and measures authority would be called in to resolve the matter. A contractual sales agreement cannot be used to circumvent legal metrology requirements. Therefore, general and specific requirements are necessary (1) as guidelines for the design, performance, and use of equipment intended for wholesale deliveries and (2) as the basis for test procedures used in the initial type evaluation and subsequent routine field tests of equipment by local weights and measures officials. Other facets of wholesale deliveries have raised questions about the application of the draft code paragraph A.1. which specifies that the code applies solely to sales based on the dynamic measurement of the mass of gaseous hydrogen. The DSS will need to determine if PVT measurements are dynamic. Draft paragraph S.1.3.1. Units of Measurement specifies deliveries only in kilograms and was initially intended for retail refueling applications. Since it appears that wholesale deliveries may be in units of standard cubic feet (SCF) rather than kilograms, the DSS will need to further research industry practices before including larger units of measurements for wholesale deliveries in the draft code.

A teleconference was schedule to focus discussions on the best approach to address wholesale applications. The tele/webconference was scheduled for June 17, 2009 from 3:00 p.m. to 5:00 p.m. EDT.

(iii) Application of Corresponding CNG Code to Hydrogen Devices

Like other organizations the USNWG has borrowed from existing codes for similar applications rather than reinvent an entirely new code for hydrogen. The DSS considered paragraphs carried over from the Mass Flow Meters (MFM) Code to determine their suitability for hydrogen refueling applications (e.g., test procedures where condensation affects the test result).

The DSS modified paragraph S.1.3.3. to fully align the requirements for the quantity-division value with those in corresponding MFM Code paragraph S.1.3.3. for gaseous refueling applications. Other areas that may need some refinement lie within the test procedures and will be addressed as the work begins in late 2009 through 2010 on field examination procedures.

(iv) Stationary versus Mobile Applications

The DSS worked to determine if there are sufficient provisions in the draft code so that it is clear as to how the requirements apply to stationary, mobile, and vehicle-mounted applications (see DSS Agenda Item (3)(b)(i)). During the DSS discussions industry representatives provided examples of various installations so that the DSS might classify them as stationary or mobile/portable applications.

The DSS applied the same criteria used in other HB 44 measuring devices codes to distinguish stationary installations from other types of refueling operations. However, the DSS does not plan to use the same approach followed in HB 44 of applying tighter performance requirements to vehicle-mounted measuring systems. It should be noted that these systems may be required to be vehicle-mounted for the entire period of type evaluation, from the initial through the permanence test phase. The DSS agreed there was no justification from a metrological standpoint to make a distinction between the requirements that apply to mobile or stationary devices. Some devices under consideration are not vehicle-mounted, but are portable because they are moved to and from various locations on a site, for example to fill aircraft. The DSS does not consider these refuelers mobile applications. The DSS explored classifying dispensers that refuel from a trailer bed as "on-board weighing systems," but on closer examination these hydrogen refueling systems are completely independent of the vehicle chassis etc. and thus do not meet the current HB 44 definition for "vehicle on-board weighing system." Consequently, they did not develop separate sets of requirements for either application.

A hydrogen refueling system has the capability to be mounted on a skid and moved to any location and installed to operate at a site where there is electricity or they may be mounted and operate on the back end of a trailer. In instances where refueling equipment is continually moved from site to site where it is hooked up to electricity, grounded, etc. but never vehicle mounted, there is an expectation that the equipment would be recalibrated for accuracy and consideration would be given to any environmental or other factors at each location that might affect its performance or indication of delivery. The weights and measures community has not had the same expectation that a vehicle-mounted measuring system be recalibrated after each road trip to a new location. There are other device types which are moved from location to location and it becomes the owner/operators responsibility to maintain these devices in an accurate state. The DSS agreed to document these operations to make the community aware that these installations exist and do fall under weights and measures' jurisdiction (see Table A below). Although the DSS agreed there would be no distinction between mobile and stationary device requirements, this subject might be revisited should conditions arise to indicate that there is a need to differentiate requirements. With the exception of paragraph UR.3.4. Ticket in Printing Device, Vehicle-Mounted Metering Systems, the draft code includes no other requirements specific to nonstationary applications. Paragraph UR.3.4. is directed at the operator of the refueler to prevent accidental or intentional misuse of the printer in billing customers.

Table A
Stationary and Nonstationary Hydrogen Refueling Dispenser Applications

System Description	Delivery Charge/ Customer Base	Measurement Methodology	Application	
			Nonstationary	Stationary
Retail Motor-Fuel Dispenser (RMFD)	*CHARGE* ▫ Flat fee for a fill up *CUSTOMER* ▫ End user (fill-up or top-off)	▫ Fill is based on pressure- volume-temperature (PVT) differential between the dispenser and receiving tank/vessel ▫ PVT values are used to calculate the quantity	Vehicle-mounted	
Tube Trailer*	*CHARGE* ▫ Payment for trailer load CUSTOMER ▫ Auto OEM Note: operators of leased cars fill up at trailer as part of lease/contract with auto OEM	Meter		Trailer parked at a single location where passenger vehicles drive in for refueling
Retail Motor-Fuel Dispenser	*CHARGE* ▫ Invoice each household *CUSTOMER* ▫ Single delivery to each household	Meter	Vehicle - mounted	

Table A Stationary and Nonstationary Hydrogen Refueling Dispenser Applications				
System Description	**Delivery Charge/ Customer Base**	**Measurement Methodology**	**Application**	
			Nonstationary	**Stationary**
Tube trailer	*CUSTOMER* ▫ Single aircraft	Meter		Trailer with its own meter is moved on and off the tarmac; where it can be to apparatus necessary for its operation such as a compressor
Retail Motor-Fuel Dispenser	*CUSTOMER* ▫ Single passenger vehicle	To be determined		RMFD moved to a service station; where it can be connected to apparatus necessary for its operation such as a compressor and tube trailers that supply hydrogen
*Tube trailer - a cluster of pressure rated vessels/tanks with approximate storage capacity of 300 kg of hydrogen gas that are transported on a semi-trailer and the contents used to supply refueling operations.				

One application that will require further evaluation is that of a "pumper trailer" in which gaseous hydrogen is metered by the standard cubic foot (SCF) rather than kilogram. Since transactions take place based on a measurement this is a commercial device. However, the DSS agreed not to recognize the SCF unit of measurement for retail vehicle refueling applications. The DSS has found the reference conditions and method(s) of calculating the quantity of gas delivered can vary industry wide in operations where charges are billed to the customer or indicated at the time of sale in the SCF. It will be necessary to study the pumper trailer industry in search of common characteristics where a single set of requirements might be appropriate for these installations.

The DSS agreed there will be no modifications to the code at this time to include specific requirements for nonstationary hydrogen vehicle refueling systems.

(v) Stakeholder Input

The DSS discussed whether or not the draft code has received sufficient review and input from all stakeholders affected by legal metrology requirements for hydrogen refueling systems. For example, have all OEMs commented on whether or not there are significant differences in their design of hydrogen dispensers that might create concerns for officials attempting to access marking information located behind a cabinet door? The DSS agreed that between the participation of its members who either represent specific sectors of stakeholders or who participate in related technical committees where hydrogen standards are under development and the distribution and posting of the USNWG's work most stakeholders are aware of its work on the weights and measures hydrogen infrastructure. Current USNWG DSS members represent (1) hydrogen dispensing systems and components manufacturers, (2) hydrogen fuel-providers, partnerships, and quality laboratories, (3) commercial measuring equipment type evaluation laboratories, (4) federal energy and commerce departments, and (5) related standards organizations. The Technical Advisor(s) will continue to encourage national and international stakeholder groups and organizations with new or renewed interest in this area of the work to provide input on the requirements under development by the DSS.

(vi) Tolerance Tables
During the April 2009 meeting, this topic was added to the list at the request of manufacturers who maintain the allowable error limits are too stringent and report accuracies of 5-10 % are only possible. These manufacturers indicated that only two meter manufacturers currently market meters for gaseous hydrogen applications. The two brands of meters are Rheonik (GE Sensing & Inspection Technologies) and Oval (Oval Corp. of Japan). It should be noted that during the December 2008 meeting two manufacturers reported that an accuracy of 1.0 % was possible.

Dan Reiswig (CA DMS) and Juana Williams (NIST) will gather performance data from international sources, industry, and the weights and measures community to prove if the 1.5 % is achievable. Since Germany, Japan, and the Netherlands will be contact since they were major contributors to the development of OIML R 139 and may be the primary location for the two hydrogen flow meters currently on the market. Dan Reiswig will contact past customers and Juana Williams will contact representatives on the OIML technical committees in those countries.

California Type Evaluation personnel indicated that there are also design differences in equipment intended for liquid and gaseous applications. For example, liquid dispensers are equipped with a vacuum jacketed hose to prevent flashing as well as differences in the equipment's pressure transducers. These design features, if deemed by the manufacturer as a necessary part of the measuring system, would need to be operable during type evaluation and subsequent routine field inspections. A feature that is necessary for accurate measurement or indications of that sale should be durable enough for field use and not be used in a fraudulent manner.

The DSS will revisit the tolerances and methods for verifying equipment is capable of meeting performance requirement at its August 2009 meeting.

(c) Opportunity for Reports on Related Activities
The DSS is working to harmonize, wherever possible, with related standards to encourage uniformity and to avoid contradictory requirements and trade barriers for U.S. industry. The DSS will receive updates on related work by organizations such as ASTM, CaFCP, NHA, OIML, SAE and others as their work continues to progress.

(i) Update on Work at CDFA DMS
Under the administration of the California Energy Commission (CEC), Assembly Bill 118 has created an Alternative Fuels and Vehicle Technologies Funding Program for the development and deployment of innovative technologies that will help California attain its climate change goals. The CEC has allocated $40 M in funding to hydrogen stations. The CDFA announced it will receive $1.6 M from the CEC for two years for the development of a test standard for hydrogen refueling equipment. Currently, Norm Ingram (DMS) is gathering bids for a gravimetric test stand equipped with a trailer. Kristin Macey (DMS) indicated it will be 6-12 months before DMS conducts tests.

(ii) Update on Work at Other Agencies/Organizations
CSA America, Inc.
Julie Cairns of CSA America, Inc. reported on the status of HGV 4.3 Temperature Compensation Devices for Hydrogen Dispensing Systems. HGV 4.3 addresses safety performance requirements for systems that adjust fill to avoid over pressurization of the vehicle's storage tank. HGV 4.3 is now a guideline with protocols for stations not using a prescriptive approach for the equipment's design. CSA acknowledges that the heat build up during fill results in poor heat transfer in the plastic liners of tanks. Currently, a fill at 70 MPa to a 1 kg tank takes 17 minutes. The smallest tank for use in the test is 26 L and the largest is 215 L. CSA is unable to obtain a 10 kg tank because the technology is proprietary. CSA is controlling the flow rate through the tank size, for slow flow using a small tank takes 17 minutes to fill and for a fast flow using a small tank or large tank takes 3 ½ minutes to fill. CSA indicates that tests to fill tanks from two-third up to full capacity are difficult to perform. CSA is beginning to develop a model to test to the requirements in HGV 4.3 because it now has the ability to test all types

of dispenser algorithms. CSA will use multiple tank sizes that are actively heated and cooled to simulate real world conditions. Each tank is weighed on a scale that is mounted on a trailer. CSA indicated that the test draft is purged to the atmosphere out of concerns about contaminants when the fuel is returned to storage. There are also restrictions for shipping product in containers even though this may be a means of sampling for product purity. Additionally, there may be safety concerns when venting hydrogen in a highly industrial area or areas where garages or other structures do not allow the gas to rapidly dissipate.

(4) Next Steps/Tasks

The DSS discussed the next steps for working through all possible gaps in the draft code and test procedures. Several upcoming projects were identified in Agenda Item (3). To ensure there are no gaps in the final code that might delay its acceptance in the weights and measures standards development process in fall 2009, the DSS identified the following topics and target dates:

- Wholesale Applications:
  - Discuss and address during the June 17, 2009 Tele/webconference
- Test Procedures:
  - Evaluate the CSA/HGV 4.3 test model and its potential for a multipurpose test standard
  - Evaluate the NIST Uncertainty Data for Gravimetric, Volumetric, and Master Meter Test Methods
- Test Data and Test Procedures (ongoing):
  - Request data from industry and weights and measures jurisdictions to support draft tolerances
  - Contact other national and international legal metrology organizations, laboratories, etc. most likely to have sufficient test data

The DSS will escalate its work to have a final draft code which is ready for approval and adoption in the weights and measures community by July 2010.

(5) Next Meeting

The USNWG discussed and will ballot its members on a change to the date and time for its upcoming August 18-20, 2009 meeting due to scheduling conflicts for multiple USNWG members. The USNWG is considering August 11-13, 2009 for its next in-person meeting. The meeting will be held on the NIST Gaithersburg, Maryland campus. Tentative plans are to hold the FSS meeting from noon to 5 p.m. on August 11^{th} and then hold the DSS meeting from 8:30 a.m. to 5:00 p.m. on August 12^{th} and 13^{th}.

Some tasks may be completed by conference calls and email, while others may require an in-person meeting of the DSS. It is anticipated that there may be a need to dedicate an entire meeting to one specific device related project that is identified by the USNWG. Future meeting locations will be based on logistics and technical tasks that the USNWG must accomplish. The USNWG will make every effort to post meeting information and to avoid scheduling conflicts with upcoming events and meetings in the weights and measures and hydrogen communities.

FUEL SPECIFICATIONS SUBCOMMITTEE (FSS) MEETING

Thursday, April 30, 2009, 8:30 a.m. – 12 noon (PDT)
California Fuel Cell Partnership
West Sacramento, CA
Chair – Robert Boyd (Linde North America, Inc.)
Technical Advisor – Lisa Warfield (NIST WMD)

(1) Welcome and Introductions

The FSS participants were welcomed inperson and on audio conference, the meeting was called to order, and its purpose reviewed. The collaborative work by the meeting's sponsors was recognized. Participants were briefed on the facilities available at the California Fuel Cell Partnership, the schedule of events, meeting procedures, and materials. Participants provided their name, affiliation, and stated their specific area of interest in the work to develop hydrogen measurement standards.

(2) Administrative Business

The FSS addressed the following:

(a) Approve the Summary of the February 2009 USNWG Meeting

The FSS approved the February 2009 meeting summary (see Appendix A) as written.

(3) Method of Sale for Hydrogen Dispensing Applications

The April 2009 meeting resulted in several modifications to the Discussion Paper "The Starting Point: A Discussion Paper Describing a Proposed Method of Sale and Quality Specification for Hydrogen Vehicle Fuel" and Draft 2.3 of the HB 130 Method of Sale and Fuel Quality requirements for hydrogen (see Appendix H) to harmonize, where possible, with the latest recommendations developed by related technical work groups.

Method of Sale Requirements

The FSS recommended marking a retail sales dispenser and signage with “HXX” to clearly identify the product and service pressure. The capital "H" is the only acceptable symbol for hydrogen vehicle fuel. Where the capital “H” precedes the “XX” it represents the service pressure of the hydrogen fuel offered for sale. The service pressure must be expressed in the SI unit megapascal (MPa), for example "H35", rather than the pascal.

Modifications will be made to the discussion paper and draft code to clarify:

- “H” as the acceptable symbol for use to identity "Hydrogen" fuel, and
- the megapascal as the appropriate SI unit of measurement for expressing the service pressure for dispenser labeling and street price sign advertisement

The use of the megapascal is a more recent practice by industry and the scientific community.

Consequently, the FSS modified the proposed new HB 130 subparagraph 2.X.X.4. 2. for labeling Street Sign Prices and Advertisement to read as follows:

<table>
<tr><td colspan="3">April 2009 FSS Modifications to
Draft 2.3 of the NIST Handbook 130 Section IV. Uniform Regulations Part B. Uniform Regulations for the Method of Sale of Commodities Section 2 Non-food Products</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Change to Requirement: Modified text in paragraph 2.XX.4.2.</td><td>Requirement Title: Street Sign Prices and Advertisements; Service Pressure</td><td>Reason for Change: Paragraph modified to specify that the megapascal is the appropriate SI unit for expressing the numerical value of the dispenser's service pressure on price signs</td></tr>
<tr><td colspan="3"><u>2.XX.4. Street Sign Prices and Advertisements.</u>

<u>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~~MPa~~).</u></td></tr>
</table>

(a) Opportunity for Reports on Related Activities
The FSS works to harmonize, wherever possible, with related standards bodies to encourage uniformity and to avoid contradictory requirements and trade barriers for U.S. industry. The FSS seeks updates on related work by organizations such as ASTM, CaFCP, NHA, OIML, SAE and other organizations as their work continues to progress.

(i) Update on Work at CDFA DMS
There were no updates reported on this topic.

(ii) Update on Work at Other Agencies/Organizations
There were no updates reported on this topic.

(4) Engine Fuel Quality

(a) Opportunity for Reports on Related Activities
The FSS is working to harmonize, where possible, with related standards to encourage uniformity and to avoid contradictory requirements and trade barriers for U.S. industry. The FSS will receive updates on related activities by other agencies/organizations.

(i) Update on Work at CDFA DMS
Under the administration of the California Energy Commission (CEC), Assembly Bill 118 has created an Alternative Fuels and Vehicle Technologies Funding Program for the development and deployment of innovative technologies that will help California attain its climate change goals. The CDFA DMS announced it will receive $1.9 M from the CEC for research on sampling and laboratory analytical methods. The funding will be used to hire staff and consultants. (see also FSS Agenda Item ((5)(a)(i))

(ii) Update on Work at Other Agencies/Organizations
The FSS received a report on the February 2009 SAE J2719 Technical Information Report on the Development of a Hydrogen Quality Guideline for Fuel Cell Vehicles. The SAE guidelines are coordinated with ISO TC197/WG12 and ASTM D03 Committee. SAE J2719 has modified its guidelines for hydrogen fuel quality

specification for impurity levels of nonhydrogen constituents, mass concentrations for particulates, and constituent terminology.

Fuel Quality Specifications
Modifications will be made to both the discussion paper and draft code for consistency with the February 2009 recommendations of SAE J2719 to:

- Identify properties where there is tentative agreement on the ability of current technology to test for the permissible limits proposed in the code,
- Update the measurement unit for the permissible level of particulate concentration, and
- Update the property terminology, measurement unit, and the value for the permissible level for particulate size

The FSS also agreed to modify proposed new HB 130 definitions for "fuel cell", "hydrogen fuel," and "internal combustion engine," to ensure the descriptions are more technically correct as shown in the table below:

April 2009 FSS Modifications to Draft 2.3 of the NIST Handbook 130 Section IV. Uniform Regulations Part G. Uniform Engine Fuels, Petroleum Products and Automotive Lubricants Regulations Section 1. Definitions		
Change to Requirement: Modified text in paragraph 1.XX.	**Requirement Title:** Fuel Cell	**Reason for Change:** Definition modified to include more technically correct language
1.XX. Fuel Cell. - an electrochemical energy conversion device ~~used to convert hydrogen and oxygen into electrical~~ in which fuel and an oxidant react to generate energy ~~to power a motor vehicle~~ without consumption of its electrodes or electrolyte.		
Change to Requirement: Modified text in paragraph 1.XX.	**Requirement Title:** Hydrogen Fuel	**Reason for Change:** Definition modified to include the term "surface vehicle" which is consistent with SAE terminology
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.		
Change to Requirement: Modified text in paragraph 1.XX.	**Requirement Title:** Internal Combustion Engine	**Reason for Change:** Definition modified to align text with the widely recognized *Bosch Automotive Handbook*
1.XX. Internal Combustion Engine. - a device used to ~~ignite hydrogen in a confined space to crate mechanical~~ generate power by converting chemical energy bound in the fuel into mechanical work to power a ~~motor~~ vehicle.		

The FSS modified the hydrogen fuel quality specification for consistency with the February 2009 SAE J2719 Technical Information Report on the Development of a Hydrogen Quality Guideline for Fuel Cell Vehicles which now specifies impurity limits for particulates in units of milligrams per kilogram of hydrogen fuel at 0 °C, 1 atm pressure at NTP in mass concentrations. Therefore, the FSS removed the existing measurement unit of microgram per liter of hydrogen fuel concentration threshold level for particulates as shown below in Table 1.

The FSS modified Table 1 to update several properties to clarify where there is tentative agreement with their associated values and the ability to test to those values with technology available today. The FSS also agreed that when a constituent (property) and its associated numerical value (defining a maximum or minimum limit) is added as a specification in Table 1, then an appropriate test method must then be identified. As test methods are identified and adopted by the FSS they will be added to Column 6 in Table 1.

April 2009 FSS Modifications to
Draft 2.3 of the NIST Handbook 130 Section IV. Uniform Regulations Part G. Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulations Section 2. Standard Fuel Specifications Proposed New Table 1. Hydrogen Fuel Quality Specification

Change to Requirement: Modified the unit of measurement for the constituent listed under Property 10	**Requirement Title:** Particulate Concentration	**Reason for Change:** Modified for consistency with the February 2009 recommendations of SAE J2719

	Property	Value	Unit	Limit	Test Method(s)
10	Particulate Concentration	1	~~µg/L@NTP (b)~~ <u>**mg/kg**</u>	Maximum	to be specified

Change to Requirement: Deleted text in Foonote b.	**Requirement Title:** Particulate Concentration	**Reason for Change:** Footnote deleted to reflect change in unit of measurement for corresponding Property 10. Subsequent footnotes will be updated to include a change in their letter designation
~~**b. Particulate Concentration is stated as µg/L@NTP = micrograms per liter of hydrogen fuel at 0 °C and at 1 atmosphere pressure (1 bar).**~~		

Change to Requirement: Modified the description, unit of measurement and limits of the constituent that is listed under Property 11	**Requirement Title:** Particulates Size	**Reason for Change:** Modified for consistency with the February 2009 recommendations of SAE J2719

	Property	Value	Unit	Limit	Test Method(s)
11	~~**Particulates Size**~~ <u>**Total Allowable Non-Hydrogen, Non-Helium**</u>	10<u>**0**</u>	~~**µm**~~	<u>**ppm v/v**</u> Maximum	to be specified

April 2009 FSS Modifications to Draft 2.3 of the NIST Handbook 130 Section IV. Uniform Regulations Part G. Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulations Section 2. Standard Fuel Specifications Proposed New Table 1. Hydrogen Fuel Quality Specification					
	Constituents				

Change to Requirement:	Requirement Title:	Reason for Change:
Modified the description of the constituent listed under Property 12	Total Gases	Modified for consistency with the February 2009 recommendations of SAE J2719

	Property	Value	Unit	Limit	Test Method(s)
12	Total Non-Hydrogen Gases	300	ppm v/v (c)	Maximum	to be specified

Currently, members of the FSS have held discussions with one laboratory facility that indicates it has the ability to test to the permitted levels in Table 1. CDFA DMS indicated that, if at some point scientific data demonstrates that levels in Table 1 are not realistic, they are willing to revisit the specification.

Initially, the FSS used the CDFA DMS's fuel quality specification as a starting point for a HB 130 standard. The FSS April 2009 modifications to the draft standard were made to further align the proposed requirement with the most recent recommendations of SAE 2719.

(5) Laboratory Manual

(a) Opportunity for Reports on Related Activities
The FSS is working to harmonize where possible with related standards to encourage uniformity and to avoid contradictory requirements and trade barriers for U.S. industry. The FSS will receive updates on related activities by other agencies/organizations.

(i) Update on Work at CDFA DMS
Under the administration of the California Energy Commission (CEC), Assembly Bill 118 has created an Alternative Fuels and Vehicle Technologies Funding Program for the development and deployment of innovative technologies that will help California attain its climate change goals. The CDFA DMS announced it will receive $1.9 M from the CEC for research on sampling and laboratory analytical methods. The funding will be used to hire staff and consultants. (see also FSS Agenda Item (4)(a)(i))

(ii) Update on Work at ASTM Committee D03 Gaseous Fuels
Curt Williams (GA Ag. Dept.) reported that Committee D03.14 on Hydrogen and Fuel Cells has 12 work items for test methods on its agenda and it is within five years of a procedure. Round robins will be necessary for precise measurements. A hydrogen quality sampling apparatus test procedure is a D03 project. Mr. Williams also noted that a "Referee Method" or "Main Method" is identified in the SAE standard, whereas groups such as ASTM identify all acceptable alternate test methods. Fuel quality technical committees are questioning the fuel cell's tolerance for sulfur levels in air and how they relate to preliminary allowable levels for sulfur specified in the current fuel quality standard.

(iii) Update on Work at NREL
NREL has formed a Task Force lead by Dr. Jim Ohi that will address how to collect a sample. Work has not yet begun on round robins or standard reference materials. Standards that are traceable to NIST will be necessary for verifying the performance of detection equipment at zero, low, and high levels of specific gases. FSS hydrogen providers noted that gases coming out of the liquefier would be as close to zero contaminants as possible. There would be no need for the purity level of hydrogen used in electronics production.

(b) Laboratory Practices and Procedures
The FSS discussed ongoing work to ensure fuel quality laboratories perform measurements that are traceable to recognized national standards. The FSS will work to promote the establishment of documented laboratory practices and procedures that encompass:

(i) Test Methods and Reproducibility Limits
There were no updates on this topic.

(ii) Equipment (minimum and recommended) Source and Cost
There were no updates on this topic.

(iii) Documentation (e.g., Standard Operating Procedures)
There were no updates on this topic.

(iv) Handling and Storage of Hydrogen Fuel
There were no updates on this topic.

(v) References and Good Laboratory Practices
There were no updates on this topic.

(vi) Minimum Training Standards for Laboratory Personnel
There were no updates on this topic.

(vii) Facilities
The Gas Technology Institute was identified as having the capability to perform quality analysis to the levels specified in the draft code.

(viii) Safety
More research is necessary on the safety of sample bottles for transport to and their storage in the fuel quality laboratory. It was noted that the group might want to consider the results of burst test underway at Powertech Labs, Inc., if the FSS plans to develop a hazardous operations procedure. It was suggested that a 40-liter DOT approved sample bottle might have sufficient capacity for quality sampling as well as equipment accuracy test for deliveries at the MMQ.

(6) Field Sampling Procedures
For some hydrogen dispenser designs samples must be gathered at the nozzle while the dispenser is in the manual override mode. Placing a flow control regulator on a dispenser to allow sampling might be detected by the system as a leak. Locating open bleed valves on a hose to obtain a steady flow rate (e.g., 1 kg/min) would not be interpreted by the system as a leak. However, any diversion of flow after product measurement would need weights and measures approval. It would be necessary to start the initial flow with the vent closed off, then once flow starts open the vent, which is then followed by the start of the sampling process. Back pressure regulators will need to be in place to protect the sample's integrity. Linde Inc. and APCI plan to set up a manual mode for sampling. Both manufacturers recommend a purge of the sample bottle, then filling to the MMQ followed by verification of the fill quantity and fuel quality. By sampling and subsequent weighing of the filled sample bottle

the procedures for accuracy and fuel quality verification take place in a one-step process in a laboratory environment. CDFA DMS is seeking a sampling method similar to that used to obtain gasoline samples that requires a relatively short period of time without the assistance of the business staff or other technicians.

(a) Opportunity for Reports on Related Activities
The FSS is working to harmonize where possible with related standards to encourage uniformity and to avoid contradictory requirements and trade barriers for U.S. industry. The FSS will receive updates on related activities by other agencies/organizations.

(b) Procedures/Guidelines
The FSS may wish to consider work to establish field sampling procedures to provide uniform inspection, sampling, and enforcement procedures to promote the protection of consumers (vehicles) and businesses from economic loss resulting from substandard product and to encourage safe practices by officials conducting inspections. It is recommended that these procedures/guidelines address:

(i) Equipment/Source/Cost
There were no updates on this topic.

(ii) Good Sampling Practice
There were no updates on this topic.

(iii) Handling, Storage, and Transportation
The FSS discussed Joe Cohen's recommended procedures for handling sample bottles. One procedure would be to place two sample bottles in series and purge them with 1 kg of hydrogen before sampling at the dispenser. One suggested procedure that might be followed in California to establish laboratory capabilities would consist of sending one bottle to CDFA DMS for analysis and the second bottle to JP Labs for analysis. Also suggested is to use sample bottles of the same lineage since different lots have different properties. Mr. Cohen is researching sample bottle cleaning techniques. One point that should be considered is the effects of holding and transportation times on a sample since gases such as oxygen begin to change after 24-36 hours. Contaminants such as sulfur and water in their natural state cling to walls of the bottle. However, the sulfur inside of the polymers in service station components and steel equipment are attacked by hydrogen. Also noted were the recent detection of an unknown translucent crystalline substance on the dispenser filter backer plate and levels of formic acid that approach the maximum limit specified in the draft code.

Agencies collecting samples will need to determine if there are special DOT or ASME requirements for transportation of the hydrogen sample bottles and if there are exemptions from requirements when doing so for noncommercial purposes.

(iv) Minimum Training Standards for Field Officials
There were no updates on this topic.

(7) Next Steps/Tasks
The FSS will continue to monitor updates to the hydrogen fuel quality standard by related standards bodies and will revisit the code to align and harmonize, wherever possible, with the latest recognized developments in corresponding standards.

(8) Next Meeting
The USNWG discussed and will ballot its members on a change to the date and time for its upcoming August 18-20, 2009 meeting due to scheduling conflicts for multiple USNWG members. The USNWG is considering August 11-13, 2009 for its next inperson meeting. The meeting will be held on the NIST Gaithersburg, Maryland campus. Tentative plans are to hold the FSS meeting from noon to 5 p.m. on August 11th and then hold the DSS meeting from 8:30 a.m. to 5:00 p.m. on August 12th and 13th.

It is anticipated that there may be a need to dedicate an entire meeting to one specific device related project that is identified by the USNWG. Future meeting locations will be based on logistics and technical tasks that the USNWG must accomplish. The USNWG will make every effort to post meeting information and to avoid scheduling conflicts with upcoming events and meetings in the weights and measures and hydrogen communities.

Appendix J

Attendee List-April 28-30, 2009
Meetings of the USNWG Hydrogen Device Standards and Fuel Specifications Subcommittees

Name	Agency	Device Standards Subcommittee (DSS) Member Yes (Y)	Fuel Specifications Subcommittee (FSS) Member Yes (Y)	Attended DSS April 28-29, 2009 Yes (Y)	Attended FSS April 30, 2009 Yes (Y)
Jackie Birdsall	Calif. Fuel Cell Partnership		Y	Y	Y
Robert Boyd	Hydrogen Solutions – Linde Group	Y	Y	Y	Y
Tina Butcher	NIST – TS WMD	Y	Y	Y	
Julie Cairns	CSA America	Y	Y	Y	
Joseph Cohen	Air Products and Chemicals, Inc.	Y	Y	Y	Y
Norm Ingram	CA – Food and Ag., Div. of Measurement Standards	Y	Y	Y	
Diane Lee	NIST – TS WMD	Y	Y	Y	Y
Kristin Macey	CA – Food and Agriculture, Division of Measurement Standards	Y	Y	Y	Y
Kenneth Ramsburg	MD Dept of Agriculture, Weights and Measures Program	Y	Y	Y	
Lisa Warfield	NIST – TS WMD	Y	Y	Y	Y
Curt Williams	Georgia Ag. Dept./ CPW Energy Consulting	Y	Y	Y	Y
Juana Williams	NIST – TS WMD	Y	Y	Y	Y
GUESTS					
Ronald Flores	CA – Food and Ag. Div. of Measurement Standards			Y	
Mark McDougall	Powertech Labs			Y	

John Mough	CA – Food and Ag. Div. of Measurement Standards				Y
Charlie Nelson	CA – Food and Ag. Div. of Measurement Standards			Y	
Dan Reiswig	CA – Food and Ag. Div. of Measurement Standards			Y	
Van Thompson	CA – Food and Ag. Div. of Measurement Standards			Y	