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

March 4-6, 2008
California Fuel Cell Partnership (CaFCP)
West Sacramento, California

DEVICE STANDARDS AND TEST PROCEDURES SUBCOMMTTEE (DSTPS)
and
FUEL SPECIFICATIONS SUBCOMMITTEE (FSS)
MEETING SUMMARIES

Subcommittee meetings are sponsored by the U.S. Department of Energy (DOE) and U.S. Department of Commerce's National Institute of Standards and Technology (NIST).

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

Background/History:
At its October 2007 meeting the USNWG agreed that the development of device and fuel standards could best be accomplished by two separate subcommittees. The Device Standards and Test Procedures Subcommittee (DSTPS) and Fuel Specifications Subcommittee (FSS) met in March 2008 on different dates with each subcommittee having separate agendas. The Subcommittees will continue this practice for future sessions.

AGENDA ITEMS

ATTACHMENTS LIST

Appendix	Related Agenda Item(s)	Title
A	(2)(a)*and**	Summary of the October 2007 USNWG Meeting
B	(2)(b)*and**	USNWG Guidelines
C	(3)*	Draft 2.1 of NIST Handbook 44 Gas Meters Code
D	(3)*	Comments on the 2nd Draft of the NIST Handbook 44 Hydrogen Gas Meters Code (27 Sep2007) – Buttler (Micro Motion)
E	(3)*	Comments on 2nd Draft of the NIST Handbook 44 Hydrogen Gas Meters Code (03Oct07) – Cohen (Air Products and Chemicals, Inc.)
F	(3)*	OIML R 81 "Dynamic Measuring Devices and Systems for Cryogenics Liquids"
G	(3)*	OIML R 139 "Compressed Gaseous Fuel Measuring Systems for Vehicles"
H	(4)-(7)**	California Division of Measurement Standards Proposal for an Interim Specification for Hydrogen Fuel (03Mar2008 version replaces the Feb2008 version distributed to the USNWG)
I	(3)*	Comments on the 2.1 Draft of the NIST Handbook 44 Hydrogen Gas Meters Code (05Mar2008) – Nelson (California Division of Measurement Standards)
J	(3)*	Summary of Comments on Drafts 2.0 and 2.1
K	(3)*	California Fuel Cell Partnership How It Works Brochure (Available through the CaFCP @ www.fuelcellpartnership.org)
L	(3)*	California Fuel Cell Partnership Station Tour Presentation
M		Attendee List
* Device Standards and Test Procedures Subcommittee		
** Fuel Specifications Subcommittee		

DEVICE STANDARDS AND TEST PROCEDURES SUBCOMMITTEE (DSTPS) MEETING
Tuesday-Wednesday, March 4, 2008, 8:30 a.m. – 5:00 p.m. (PT)
California Fuel Cell Partnership, 3300 Industrial Blvd., Dr. Lloyd Conference Room
West Sacramento, CA 95691
Moderator – Juana Williams (NIST WMD)

(1) Welcome and Introductions
The Moderator welcomed the participants, called the meeting to order, and covered the meeting objectives. The collaborative work by the meeting's sponsors, DOE and NIST, was recognized. Participants were briefed on the facilities available at the CaFCP, 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 (See Appendix M).

(2) Administrative Business
The DSTPS discussed procedures for managing the work group and its' subcommittees and documenting its technical work. The following items were addressed:

(a) Approve the Summary of the October 2007 USNWG Meeting
The October 2007 Summary was approved after changes were made to reflect that the SAE document on hydrogen quality is a technical information report rather than a standard.

(b) Approve the USNWG Guidelines
The DSTPS Technical Advisor requested the Subcommittee review the draft USNWG Guidelines and submit their comments by March 25, 2008. The guidelines describe the work group and its subcommittee's objectives, general membership, meeting and voting procedures, and timelines for projects and other tasks. The Technical Advisor will electronically ballot the DSTPS for their approval of future drafts of the guidelines.

(c) Elect a USNWG Chairperson
The DSTPS elected Kristin Macey, California Department of Food and Agriculture, Division of Measurement Standards (CDFA/DMS). The Chair acts in a national capacity to ensure the work progresses satisfactorily and in a timely fashion to develop appropriate legal metrology standards.

(3) Development of Device Standards and Test Procedures for Commercial Hydrogen Measurement
The USNWG is working within an existing network of experts in the weights and measures and hydrogen communities to develop a set of standards that are appropriate for commercial hydrogen measurements. The DSTPS is focusing on commercial hydrogen measurement standards necessary to support the hydrogen economy that include: (1) device and related equipment codes, (2) inspection procedures, test equipment standards, and safety practices, (3) training for officials and service companies, and (4) education of the public on hydrogen measurement. The DSTPS was advised that a variety of metering technologies, such as mass flow meters and sonic nozzles might at some point need to be addressed in the codes. The DSTPS resumed work on Draft 2.1 of the NIST H44 Hydrogen Gas Meters Code addressing the October 2007 and March 2008 comments (see Appendices D, E, and I, or J) the Subcommittee received on the code.

The DSTPS made changes to draft 2.1 of the NIST Handbook 44 Hydrogen Gas Meters Code based on comments from industry and Weights and Measures officials to address: (1) marking temperature ranges; (2) pressurization of the hose; (3) units of measurement; (4) selection of the unit price; (5) receipt requirements in retail applications; and (6) the appropriate flow rate for a performance test at the declared minimum measured quantity (Buttler, Keilty, Richter will provide feedback). The draft will also be revised to clarify how product composition relates to meter technology and to define the terms nonresettable totalizer and minimum measured quantity. A third draft code that incorporates all of the changes noted above and in the table below will be made available for electronic review by the DSTPS shortly.

The DSTPS discussions covered the following topics:

Industry and Other Standards
The DSTPS has concerns about the differences in standard conditions recognized by various standard bodies, groups, and organizations. The unit of measurement in use to identify pressure on dispensing system is the "bar." The DSTPS is recommending use of the conversion factor of 1 bar = 14.5 psi, which is recommended by the Canadian Standards Association.

Test Procedures and Test Data
Several dispenser OEMs are working to provide performance data to the DSTPS for comparison with current accuracy requirements in the draft code. CDFA/ DMS is nearing completion of a checklist procedure for approving dispensers and working to obtain a mobile gravimetric test unit so that CDFA/ DMS can begin gathering data. With over 20 hydrogen stations, CDFA /DMS anticipates it will be the first state to receive a request for approving a hydrogen dispenser for commercial use. The USNWG had lengthy discussions about (1) how to simulate real world filling conditions to 1/3, 2/3, and 3/3 vehicle tank capacity, (2) test dispenser accuracy using either a gravimetric, volumetric, or transfer standard. It is anticipated that field test procedures for commercial equipment will be the primary focus of the upcoming May/June 2008 meeting.

The DSTPS has concerns about control of the delivery to simulate the required flow rates and quantities during test of the systems. The DSTPS discussed the ability of laboratories and field officials to throttle tank valves or vent tanks to control delievery rates. Systems operating at 700 bar would not allow for throttling the test tank valves since the filling is off the compressor. The DSTPS will consider a recommendation for using a small tank to simulate fill into an almost full tank and for performance tests at the minimum measured quantity.

Test Standards
The DSTPS agreed to include text to recognize transfer standards. The DSTPS Technical Advisor noted that a NIST 105 Series (Specifications and Tolerances for Reference Standards and Field Standard Weights and Measures) for master meters is only in the early stages of development.

Code Revisions
Paragraphs modified by the DSTPS during the March 2008 meeting and the rationale for their actions are as follows:

March 2008 DSTPS Modifications to Draft 2.1 of the NIST Handbook 44 Hydrogen Gas Meter Code		
Change to Requirement: Added Example to Paragraph S.1.3.2.	Requirement Title: Numerical Value of Quantity-Value Divisions	Reason for Change: Clarified the difference between an acceptable numerical value and units of measurement for quantity divisions

S.1.3.2. Numerical Value of Quantity-Value Divisions. - The value of a scale interval shall be equal to:

- 1, 2, or 5, or
- a decimal multiple or submultiple of 1, 2, or 5.

Examples: quantity-value divisions may be 10, 20, 50, 100; or 0.01, 0.02, 0.05; or 0.1, 0.2, or 0.5 etc.

Change to Requirement: Modified Paragraph S.2.7.	Requirement Title: Recorded Representation, Point of Sale Systems	Reason for Change: Clarify that a printed sales receipt is required on hydrogen motor-fuel systems

S.2.7. Recorded Representations, Point of Sale Systems. – **A printed receipt shall be available through a built-in or separate recording element for transactions conducted with point-of-sale systems or devices activated by debit cards, credit cards, and/or cash.** The sales information ~~**recorded by cash registers when interfaced with a retail motor-fuel dispenser**~~ shall contain the following information for products delivered by the dispenser:

(a) the total mass of the delivery,

(b) the unit price,

(c) the total computed price, and

(d) the product identity by name, symbol, abbreviation, or code number.

Change to Requirement: Modified Paragraph S.3.5.	Requirement Title: Automatic Density Correction	Reason for Change: Added text to explain composition as it relates to technology

S.3.5. Automatic Density Correction.

An automatic means to determine and correct for changes in product density shall be incorporated in any hydrogen gas metering system **where measurements** are affected by changes in the density (e.g., **the effects of** temperature, pressure, or **variations in** composition **due to the feedstock, processing, storage, or the environment**) of the product being measured.

Change to Requirement: Modified Paragraph S.3.6. and Paragraph Title	Requirement Title: Pressurization of Discharge Hose	Reason for Change: Changed the term "pressure" to "pressurization." Added missing text to last sentence to clarify indications must not

		advance during purging or bleeding of the discharge hose

S.3.6. Pressurizing the Discharge Hose. - The discharge hose for hydrogen gas shall automatically **pressurize to pressure equal to the receiving vessel** prior to the device beginning to register the delivery. **Initial hose pressurization shall not advance the indications.**

The discharge hose shall be repressurized at the beginning of a delivery when venting occurs at the end of the fueling operation. Purging/Bleeding of the discharge hose shall not advance the indications.

Change to Requirement: Modified Paragraph S.3.7.(c)	Requirement Title: Zero Set-Back Interlock, Retail Motor-Fuel Devices	Reason for Change: Changed the term "pump" to "source" to recognize the difference in how hydrogen supply systems operate

S.3.7. Zero-Set-Back Interlock, Retail Motor-Fuel Devices. - A device shall be constructed so that:

(c) in a system with more than one dispenser supplied by a single ~~pump~~ **source**, an effective automatic control valve in each dispenser prevents product from being delivered until the indicating elements on that dispenser are in a correct zero position.

Change to Requirement: Modified Paragraph S.5 (f)	Requirement Title: Markings; Flow Rates	Reason for Change: Deleted the term pound

S.5. Markings. - A measuring system shall be conspicuously, legibly, and indelibly marked with the following information:

(f) maximum and minimum flow rates in **kilograms ~~or pounds~~** per unit of time;

Change to Requirement: Modified Paragraph S.5.(h)	Requirement Title: Markings; Applicable Range of Temperature	Reason for Change: Clarified that the device must be marked with the ambient temperature range at which the system operates if it is other than 10 °C to +50 °C

S.5. Markings. - A measuring system shall be conspicuously, legibly, and indelibly marked with the following information:

(h) applicable range of **ambient** temperature if other than -10 °C to +50 °C;

Change to Requirement: Added a new Note to Paragraph S.7.	Requirement Title: Totalizers for Retail Motor-Fuel Devices	Reason for Change: Clarified the purpose of a nonresettable totalizers by providing examples of how they are used.
S.7. Totalizers for Retail Motor-Fuel Devices. - Retail motor-fuel dispensers shall be equipped with a nonresettable totalizer for the quantity delivered through each separate metering device. **Note: Examples of possible uses that necessitate a nonresettable totalizer include, but are not limited to: (1) tracking product dispensed during test, (2) detecting diversion of product after it is metered, (3) detecting discrepancies between blend settings and posted octane values, (4) detecting use after the device is removed from service, and (5) collection of motor-fuel taxes.**		
Change to Requirement: Added a new Paragraph N.4.1	Requirement Title: Transfer Standard Test	Reason for Change: Added new text to recognize the transfer standard test method and an appropriate size for the test draft
N.4. Tests **N.4.1. Transfer Standard Test. - When comparing a meter with a calibrated transfer standard, the test draft shall be equal to at least the amount delivered by the device in two minutes at its maximum discharge rate.**		
Change to Requirement: Added a new Paragraph N.4.2	Requirement Title: Gravimetric Test	Reason for Change: Added new text to recognize the gravimetric test method and an appropriate size for the test draft
N.4. Tests **N.4.2. Gravimetric Test. – The weight of the test drafts shall be equal to at least the amount delivered by the device in two minutes at its maximum discharge rate.**		
Change to Requirement: Modified text in existing Paragraph N.5	Requirement Title: Minimum Measured Quantity	Reason for Change: Renumbered Paragraph from N.4 to N.5 and modified text to clarify that the flow rate at which a device must undergo performance test for delivery of the minimum measured

		quantity.
N.45. Minimum Measured Quantity. - The device shall be tested for a delivery equal to the declared minimum measured quantity when the device is likely to be used to make deliveries on the order of the **declared** minimum measured quantity. **Any minimum measured quantity test shall be made at the minimum flow rate of the installation.**		
Change to Requirement: Modified Paragraph N.7	Requirement Title: Density	Reason for Change: Modified to reflect current and upcoming standards reference information available by mid summer 2008.
See draft code.		
Change to Requirement: Added new Paragraph T.4.2.	Requirement Title: Tolerance Applications; Transfer Standard	Reason for Change: Added text to specify how tolerances are applied when verifying standards using the transfer standard test method
T.4. Tolerance Application. **T.4.2 To the basic tolerance values that would otherwise be applied, there shall be added an amount equal to two times the standard deviation of the applicable transfer standard when compared to a basic reference standard.**		
Change to Requirement: Modified Paragraph UR.1.3.(b)	Requirement Title: Minimum Measured Quantity	Reason for Change: Clarified that a manufacturer and weights and measures authority may specify minimum measured quantities for a device and performance requirements apply to either quantity when that minimum measured quantity is likely to be the delivery.
UR.1.3. Minimum Measured Quantity. (b)The minimum measured quantity appropriate for a transaction may be specified by the weights and measures authority. A device may have a **declared** minimum measured quantity smaller than that specified by the weights and measures authority; however, the device must perform within performance requirements for the declared **or specified** minimum measured quantity **up to deliveries at the maximum measurement range**.		

Change to Requirement: Modified Paragraph UR.2.2.	Requirement Title: Discharge Rate	Reason for Change: Added text to recognize that some system's are designed to reach maximum flow rate only after initial equalization, then delivery occurs
UR.2.2. Discharge Rate. - A device shall be installed so that **after initial equalization** the actual maximum discharge rate will not exceed the rated maximum discharge rate. Automatic means of flow regulation shall be incorporated in the installation if necessary.		
Change to Requirement: Modified Paragraph UR.3.8.	Requirement Title: Conversion Factors	Reason for Change: Deleted the term pound
UR.3.~~9~~8. Conversion Factors. – Established conversion values (see references in N.~~6~~7) shall be used whenever metered hydrogen gas is billed. All sales shall be based on ~~grams or~~ kilograms ~~or pounds~~.		
Change to Requirement: Added a new definition to Appendix D	Definition Title: Minimum Measured Quantity	Reason for Change: Clarified the special meaning of the term used in the code.
minimum measured quantity (mmq). The smallest quantity delivered for which the measurement is accurate for that system.[3.37, 3.3X]		
Change to Requirement: Added a new definition to Appendix D	Definition Title: Nonresettable Totalizer	Reason for Change: Clarified the special meaning of the term used in the code.
nonresettable totalizer. An element interfaced with the measuring or weighing element that indicates the cumulative registration of the measured quantity with no means to return to zero.[3.30, 3.37, 3.3X]		

(4) Next Steps/Tasks

The DSTPS discussed ideas for how the work should progress to complete the work on equipment standards and the next phase of its work to develop corresponding test procedures. Project work was identified on the following subjects:

Composition

Various metering technologies may be used to deliver hydrogen where the affects of pressure, temperature, and composition may affect product density. The measurements made by some meter technologies may need to be corrected for changes in any factors that affect measurement accuracy so the device can meet performance requirements.

Test Procedures
The DSTP requested that participants forward test data which demonstrates that the current 1.5% accuracy tolerance in the draft code is appropriate

The DSTPS discussed work by the CDFA/DMS to develop a draft checklist of test criteria for the type evaluation of hydrogen dispensers. Equipment OEMs questioned if there is reciprocity in the 50 states for type evaluation test data. There are only limited agreements for reciprocity among the 50 States; however, most states participate in the NCWM National Type Evaluation Program. Since there is no nationally recognized hydrogen code, then a checklist would be based on ad hoc procedures derived from existing codes. Manufacturers were interested in the process whereby other jurisdictions might recognize the CDFA/DMS test results and permit the commercial use of hydrogen dispensers in their states.

(5) Next Meeting
At the conclusion of the March 5 meeting the DSTPS discussed possible locations for a May/June 2008 meeting. The three sites suggested were the Gas Technology Institute (Des Plaines, IL), Air Products and Chemicals, Inc. (Allentown, PA) and the southern California site of an upcoming meeting for the fuel cell industry. The USNWG will correspond by email to determine the location of the next meeting. Future meeting locations will be based on logistics and technical tasks that the USNWG must accomplish.

The DSTPS agreed that invitations should be extended to automobile manufacturers and energy providers for their input and participation in anticipation of their resistance to requirements for specific fueling protocols.

(6) USNWG - Technology Tours
On March 5, 2008, the USNWG had the opportunity to participate in a Ride and Drive Tour of hydrogen fuel cell vehicles at the California Fuel Cell Partnership (CaFCP) in West Sacramento and tour the hydrogen refueling system at the Sacramento Municipal Utilities District (SMUD) in Sacramento. The USNWG was able to observe the latest hydrogen transportation and refueling technology. The USNWG wishes to express its deepest appreciation to the CaFCP, SMUD, and Air Products and Chemicals, Inc. for this learning experience.

FUEL SPECIFICATIONS SUBCOMMITTEE (FSS) MEETING

Thursday March 6, 2008, 8:30 a.m. – 12 noon (PT)
California Fuel Cell Partnership, 3300 Industrial Blvd., Dr. Lloyd Conference Room
West Sacramento, CA 95691
Moderator – Kenneth Butcher (NIST WMD)

(1) Welcome and Introductions
The FSS was welcomed, the meeting called to order, and the FSS objectives were covered. The collaborative work by the meeting's sponsors, DOE and NIST was recognized. Participants were briefed on the facilities available at the CaFCP, the schedule of events, meeting administrative procedures, and materials. Participants were invited to provide their name, affiliation, and state their specific area of interest in the work to develop a hydrogen fuel specification.

Due to the time constraints of the meeting the administrative tasks of nominating a Chair and distribution of the USNWG guidelines were covered in this session. The FSS did not have any nominations for Chair of the FSS at this time. The FSS was encouraged to agree on candidate(s) by the next meeting. The appointment of a Chair is important given the size of the task before the FSS to ensure and promote the development of appropriate and fair: (1) method of sale requirements, (2) labeling requirements, (3) fuel

quality standards, (4) sampling procedures, (5) field and laboratory inspection procedures, test equipment standards, and safety practices, and (7) training for officials and laboratories in support of the hydrogen economy.

The FSS was asked to review and comments on the draft USNWG Guidelines from the DSTPS by March 25, 2008. The guidelines describe the work group and its subcommittee's objectives, general membership, meeting and voting procedures, and timelines for projects and other tasks. The FSS will be balloted electronically for their comments and approval of the guidelines.

(2) Background and History

Typically, motor-fuel quality standards are developed by standards bodies other than those working directly with the weights and measures community. The weights and measures community may have members participating in the work of those Standards and Code Developing Organizations. The USNWG will not change that process nor develop the fuel quality standard, but will eventually recommend quality and other related weights and measures laws (definitions, specifications, and method of sale) that should be included in NIST Handbook 130. NIST Handbook 130 is a compilation of the latest uniform standards, related interpretations, and guidelines in the areas of legal metrology and engine fuel quality. States may choose to adopt Handbook 130 as law and regulation. States then establish and administer programs that monitor and enforce method of sale and fuel specification laws.

Work is under way within the global hydrogen community to establish fuel specifications, sampling procedures, and identify test equipment to determine acceptable levels of purity and contaminants, other elements, and particulates for hydrogen refueling applications. The FSS discussed the status of ongoing work to address hydrogen fuel specifications by the International Organization for Standardization (ISO) Technical Committee 197 Working Group 12, California Department of Food and Agriculture Division of Measurement Standards (DMS) (see Appendix H), and the Technical Information Report developed under the SAE Standard J2719. Research is ongoing to determine if it is feasible for products to meet projected specifications and to ascertain if laboratories are capable of making measurements to proposed standards. The FSS is interested in data analysis on contaminant sources such as the environment, motor-fuel dispensing system, sampling methods/equipment, and/or feedstock.

In its October 2007 meeting, the USNWG recommended an approach that set the limits for hydrogen fuel purity on a percentage basis. The USNWG discussed the allowable limits for hydrogen purity and its affects on the accuracy of refueling equipment when measurements are influenced by a product's molecular weight. The FSS is in agreement with the USNWG's earlier decision that impurities up to 0.03 % would not have a significant affect on measurement accuracy.

(3) Method of Sale for Hydrogen Dispensing Applications
The FSS was asked to consider proposals developed by NIST to amend NIST Handbook 130 to recognize hydrogen refueling applications to address the method of sale, define what products fall under this application, and device labeling for hydrogen dispensers. The FSS also agreed that unit pricing in decimal cents should be prohibited since this practice did not represent a better value.

The FSS agreed with the October 2007 decision of the USNWG to meter hydrogen in mass units of the kilogram which has an energy value similar to that of a gallon of gasoline. Consequently, the kilogram becomes acceptable from a metrological and consumer standpoint.

The first proposal would modify NIST Handbook 130 Section IV. Uniform Regulations Part B. Uniform Regulations for the Method of Sale of Commodities Section 2 Non-food Products. The proposal would include a definition for "hydrogen fuel" that is taken from language developed by the California Division of Measurement Standards. The proposed language is worded similarly to current NIST Handbook 130 text which addresses corresponding requirements for compressed natural gas dispensers and reads as follows:

2.XX. Retail Sales of Hydrogen Fuel.

2.XX.1. Definition.

2.XX.1.1. Hydrogen Fuel. - Means a fuel composed of the chemical hydrogen intended for consumption in an internal combustion engine or fuel cell.

2.XX.2. Method of Retail Sale and Dispenser Labeling.

2.XX.2.1. Method of Retail Sale. - All hydrogen fuel kept, offered, or exposed for sale and sold at retail shall be in terms of the kilogram.

2.XX.2.2. Dispenser Labeling. - All retail hydrogen fuel dispensers shall display the unit price in terms of price per kilogram.

2.XX.2.3. Street Sign Prices and Advertisements. – When the unit price of hydrogen fuel is shown on street signs and or in any advertisement it shall be in terms of price per kilogram (e.g., "$3.49 per kg".

When signage is available there should be agreement on the prices displayed on the dispenser and sign. Additionally any condition of sale, which result in a difference in prices for the same product, should also be part of the advertisement.

Although a definition for hydrogen fuel is proposed for the method of sale requirements a corresponding definitions is also proposed for NIST Handbook 130 Section IV. Uniform Regulations Part G. Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulations Section 1. Definitions to read as follows:

1.XX. Hydrogen fuel means a fuel composed of the chemical hydrogen intended for consumption in an internal combustion engine or fuel cell.

At the conclusion of its March 2008 Meeting, the FSS agreed that the conditions for sale should be stated with the associated price in whole cents/kilogram in street signage and dispenser labeling. The draft text

will be revised to include the recommended and other editorial changes and distributed for the FSS's review and input.

(4) Engine Fuel Quality

The FSS discussed the many similarities between the fuel specification draft standards and reports issued by the CDFA/DMS, ISO, and SAE and reviewed draft proposals for model fuel quality guidelines for NIST Handbook 130. The FSS discussed the effects on hydrogen fuel composition when impurities and particulates reach the maximum allowable levels listed in the CDFA/DMS draft quality standard. The FSS agreed to consider the CDFA/DMS standard as a starting point for a fuel quality specifications for hydrogen. The FSS was in agreement on the maximum allowable levels of helium, nitrogen, argon, oxygen, total gases and hydrocarbons, and water. Questions were raised about the capability of today's equipment to detect even the maximum allowable levels of ammonia, carbon dioxide, carbon monoxide, formaldehyde, formic acid, particulates, and total halogenated and sulfur compounds in the draft standard. The FSS would like to see what research will yield on the best approach to detect and determine these contaminants. The FSS is interested in what that data reveals about the full relevance of these contaminants at these levels on technology and properties of hydrogen. The FSS also has questions about the start of round robins, readiness of laboratory instrumentation, and the availability of standard reference materials.

The CDFA/DMS standard was about to complete its public review cycle. CDFA/DMS indicated the March 3, 2008 draft is an interim standard until an ANSI recognized body publishes some other quality standard. Once a hydrogen fuel quality standard is adopted it will be cited in NIST Handbook 130 Section IV. Uniform Regulations Part G. Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulations Section 2. Standard Fuel Specifications. Section 3. Classification and Method of Sale of Petroleum Products may need to be amended to recognize nonpetroleum products and specify allowable terms and abbreviations for identifying hydrogen fuel and the pressures for dispenser applications.

(5) Accurate Measurement of Water Vapor Concentration

Accurate measurement of water vapor concentration directly relates to the determination of hydrogen fuel purity on a percentage basis and hydrogen fuel density. Water vapor is considered one of the most significant contaminants included in the hydrogen fuel specification. In the current ISO TC197 standard and SAE J2719 report, it is specified as 5 PPM by volume. This water vapor concentration corresponds to a frost-point of -65.6 °C at one atmospheric pressure with a hydrogen gas density of 0.00531 grams per cubic meter in which the density of water vapor is 0.00520 grams per meter and the density of hydrogen is 0.00011 grams per cubic meter. Therefore, the FSS was asked to carefully consider the use of hydrogen fuel density in metering.

This topic involves the expanded uncertainty (k=2) in water vapor concentration for hydrogen fuel specifications, which is proportional to the square root of the sum of relative standard uncertainties of the enhancement factor, the total pressure, and the saturation water vapor pressure. The uncertainty in the enhancement factor is directly proportional to the uncertainty in the second virial coefficient for water, with hydrogen representing the interaction between water molecules and hydrogen molecules. A high accuracy second virial coefficient for hydrogen-water mixture has recently become available (see Peter Huang, "Thermodynamic Properties of Hydrogen-Water Vapor and Air-Water Vapor Mixture in Fuel Cells," ECS Trans. 5, (1) 613 (2007)).

(6) Laboratory Manual

The FSS did not have the opportunity to discuss the ongoing work to ensure fuel quality laboratories perform measurements that are traceable to recognized national standards. The FSS will need to consider the best approach to promote the establishment of documented laboratory practices and procedures that encompass:

(a) Test Methods and Reproducibility Limits

(b) Equipment (minimum and recommended) Source and Cost

(c) Documentation (e.g., Standard Operating Procedures)

(d) Handling and Storage of Hydrogen Fuel

(e) References and Good Laboratory Practices

(f) Minimum Training Standards for Laboratory Personnel

(g) Facilities

(h) Safety

(7) Field Sampling Procedures

The USNWG anticipates there are two separate tests that will need to be performed by weights and measures/fuel quality officials. The first is an accuracy test of the dispenser system and the second is sampling hydrogen delivered at high pressures for compliance with quality specifications. The FSS considered the capability of existing sampling equipment and learned firsthand about a first generation sampling device now in the possession of CDFA/DMS. The FSS will be asked to consider field sampling methods and equipment that ensure uniform inspection, sampling, and enforcement procedures to promote and ensure the protection of consumers (vehicles) and businesses from economic loss resulting from substandard product and to encourage safe practices by officials conducting inspections. The initial recommendations are for developing procedures/guidelines that address:

(a) Equipment/Source/Cost

(b) Good Sampling Practice

(c) Handling, storage, and transportation

(d) Minimum Training Standards for Field Officials

(8) Next Steps

The FSS agreed that the technology in use to determine fuel quality is an emerging one and must be monitored closely to stay current with the latest and most appropriate method and equipment for analysis. The FSS will continue researching the status of this work as it considers how future work should progress and before it modifies existing recommendations or develops new proposals.

(9) Next Meeting

Three sites suggested were the Gas Technology Institute (Des Plaines, IL), Air Products and Chemicals, Inc. (Allentown, PA) and the southern California site of an upcoming meeting for the fuel cell industry. Future meeting locations will be based on logistics and the technical needs outlined by the FFS.

The FSS, like the DSTPS, agreed that invitations should be extended to automobile manufacturers and energy providers for their input and participation in anticipation of their resistance to requirements for specific uniform pricing units and fueling protocols.

Appendix M							
Attendee List USNWG Hydrogen Device Standards and Test Procedures and Fuel Specifications Subcommittees							
Name	Agency	Phone	Email	Device Standards and Test Procedures Sub-commitee Member Yes (Y)	Fuel Specifica-tions Sub-committee Member Yes (Y)	Attended Device Standards and Test Procedure Sub-committee Meeting Yes (Y)	Attended Fuel Specifications Subcommittee Meeting Yes (Y)
Jacquelyn Birdsall	California Fuel Cell Partnership	916-375-7421	jbirdall@cafcp.org		Y	Y	Y
Robert Boyd	Hydrogen Solutions – Linde Group	510-786-5903	bob.boyd@linde.com	Y	Y	Y	Y
Kenneth Butcher	NIST-TS WMD	301-975-4859	kenneth.butcher@nist.gov		Y	Y	Y
Tina Butcher	NIST – TS WMD	301-975-2196	tina.butcher@nist.gov	Y	Y		
Marc Buttler	Micro Motion/Emerson Process Management	303-530-8562	marc.buttler@emersonprocess.com	Y	Y	Y	Y
Joseph Cohen	Air Products and Chemicals, Inc.	610-481-7625	cohenjp@airproducts.com	Y	Y	Y	Y
Jared Hightower	Greefield	972-889-2400 Ext. 129	Jared.Hightower@us.atlascopco.com	Y	Y	Y	Y
Robert Ingram	CA – Food and Agriculture, Division of Measurement Standards	916-229-3016	ningram@cdfa.ca.gov	Y	Y	Y	Y
Michael	Endress &	303-823-5796	michael.keilty@us.endress.com	Y	Y	Y	Y

Keilty	Hauser Flowtec AG						
Kristin Macey	CA – Food and Agriculture, Division of Measurement Standards	916-229-3044	kmacey@cdfa.ca.gov	Y	Y	Y	Y
Jonathan Munetz	Sentech, Inc.	202-586-6644	jonathan.munetz@ee.doe.gov	Y	Y	Y	Y
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David Pearce	Greenfield Compression	972-889-2400 Ext. 134	dave.pearce@us.atlascopco.com				
Kenneth Ramsburg	MD Dept of Agriculture, Weights and Measures Program	410-841-5790	ramsburk@mda.state.md.us	Y	Y	Y	Y
Ralph Richter	NIST – TS WMD	301-975-3997	ralph.richter.@nist.gov	Y	Y	Y	Y
Antonio Ruiz	DOE	202-586-0729		Y	Y	Y	Y
James Scott	Praxair, Inc.	716-879-2596	jim_scott@praxair.com				
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Guests							
Name	Agency	Phone	Email	Device Standards and Test Procedures Subcommittee Member **Yes (Y)**	Fuel Specifications Subcommittee Member **Yes (Y)**	Attended Device Standards and Test Procedure Subcommittee Meeting Yes (Y)	Attended Fuel Specifications Subcommittee Meeting Yes (Y)
Gerhard Achtelik	CA Air Resources Board		gachteli@arb.ca.gov				
Nico Bouwkamp	California Fuel Cell Partnership		nbouwkamp@cafcp.org			Y	Y
Rob Burgess	Hydrogen Technologies and Systems National Renewable Energy Laboratory		robert_burgess@nrel.gov				
Gary Castro	CA Dept. of		gcastro@cdfa.ca.gov				Y

	Food and Agriculture Div. of Measurement Standards						
Ben Deal	CA Air Resources Board						Y
Al Hebert	CA Dept. of Food and Agriculture Div. of Measurement Standards		ahebert@cdfa.ca.gov			Y	Y
Peter Huang	NIST Chemical Science and Technology Laboratory,		Peter.huang@nist.gov			Y	Y
Steve Huffman	Air Products and Chemicals, Inc.						Y
Dr. Hsu							Y
John Mough	CA Dept. of Food and Agriculture Div. of Measurement Standards					Y	Y
Charles Nelson	CA Dept. of Food and Agriculture Div. of Measurement					Y	

	Standards						
Van Thompson	CA Dept. of Food and Agriculture Div. of Measurement Standards	916-229-3025	vthompson@cdfa.ca.gov			Y	Y