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

December 2-4, 2008
MicroMotion, Inc.
Boulder, CO

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

MEETING SUMMARIES

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

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

AGENDA ITEMS

NOTE: Appendices A-H to the Meeting Summaries are available on request.

Devices Standards Subcommittee (DSS) Agenda

Fuel Specifications Subcommittee (FSS) Agenda

Attachments List		
Appendix	**Related Agenda Items(s)**	
A	2(a)* and **	Summary of the August 2008 USNWG Meeting
B	3(c)*	Draft 3.2 of NIST Handbook 44 Gas Measuring Devices Code
C	3** and 4**	Draft 2.2 of NIST Handbook 130 Uniform Laws and Regulations, Engine Fuel Quality
D	3**	Federal Trade Commission (FTC) Guide for Labeling Alternative Fuels
E	3(a)*	Hydrogen Gas Test Procedures Agenda
F	3(a)*	Hydrogen Test Methods Assessment-Options, Pros, and Cons
G	3(a)*	Draft EPO No. 29 Examination Procedure Outline for Hydrogen Gas Retail Motor-Fuel Dispensers
H	3(a)*	Coriolis Hydrogen Fast Fill Testing at Powertech
I	2(a)* and **	Attendee List
***Device Standards Subcommittee (DSS)**		
****Fuel Specifications Subcommittee (FSS)**		

DEVICE STANDARDS SUBCOMMITTEE (DSS) MEETING
Tuesday, December 2, 2008, 8:30 a.m. – 5:00 p.m. (MT)
Wednesday, December 3, 2008, 9:00 a.m. – 5:00 p.m. (MT)
MicroMotion, Inc., 7070 Winchester Circle
Boulder, CO
Chair – Kristin Macey (CDFA DMS)
Technical Advisor – Juana Williams (NIST WMD)

(1) Welcome and Introductions
The DSS participants were welcomed in-person 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 MicroMotion, Inc., 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 discussed and decided on procedures for managing and documenting its technical work. The following items were addressed:

(a) Approve the Summary of the August 2008 USNWG Meeting
The DSS agreed that modifications were necessary to the text in Agenda Item 3(a) Design Specifications to clarify that the design of the dispenser nozzle and the receptacle for hydrogen product allow a small amount of air from the environment to be trapped during pressurization of the hose, which results in contamination of the fuel entering an in-line sample bottle or vehicle storage tank.

The DSS agreed that the text in Agenda Item 3(b) Performance Tests should also be modified to clarify that although there is no final fuel quality standard published by a nationally recognized standards body, the DSS is moving forward with an interim standard.

The DSS agreed to approve the August 2008 meeting summary (See Appendix A) with the aforementioned modifications. USNWG meeting minutes are available on the NIST Weights and Measures web site at http://www.nist.gov/owm.

(b) Subcommittee Name Change
The DSS agreed that as of December 2, 2008 the Device Standards and Test Procedures Subcommittee (DSTPS) will be known as the Device Standards Subcommittee (DSS). This is only a name change and does not change the scope of the work by this subcommittee.

(c) Approve the USNWG Guidelines
A draft of the USNWG Guidelines incorporating the USNWG's comments from June 2008 and associated Agenda Submission Form were distributed to the USNWG August 17, 2008. During the August 26-27, 2008 meeting the USNWG agreed that the Technical Advisor should ballot the USNWG by email for its approval of the USNWG Guidelines and Agenda Submission Form due to time constraints.

During the December 2008 meeting, the DSS requested that the Technical Advisor redistribute the August 2008 version of the USNWG Guidelines and Agenda Submission Form and ballot the subcommittee by December 9, 2008 for its approval of both documents. Members of the DSS should complete their review and return any comments and vote to the Technical Advisor by January 9, 2009. Members agreed that in instances where a member does not respond by the deadline, then that particular vote will count in favor of the guidelines and form. The deadline for voting results was moved to January 21, 2009.

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

(a) Test Procedures

The establishment of proper test methods is key to instilling confidence in commercial measurements in this sector of the hydrogen economy. Consequently, the USNWG recommended that work be carried out simultaneously to develop equipment standards and test procedures.

In August 2008 the DSS agreed to postpone its discussions of the minimum test draft and tank sizes necessary to simulate various fills (e.g., 1/3, 2/3, and 3/3 fill) so that it could harmonize, wherever possible, with SAE guidelines on a fill protocol to be published in December 2008. However, the SAE did not plan to publish its technical report until late January 2009. SAE agreed there will be five test tanks of the same design used in vehicles. These tanks are classified as Type III (composite with metal liner) and Type IV (composite with a polymer liner) and should range in capacity sizes from 1.2 kg up to 9.8 kg compressed gaseous hydrogen. Estimates are that the fill content would represent 3 % to 5 % of the total weight of the filled tank. The test standard would be mounted on a sled with a rectangular framework that includes temperature and pressure sensors, data acquisition instruments, as well as piping to connect to the dispenser nozzle and vent stack.

The hydrogen and weights and measures communities provided only a limited response to the USNWG's request for test procedures and types of equipment that are currently in use to verify the performance of hydrogen refueling equipment. The USNWG is moving ahead to establish preliminary minimum specifications for standards, suitable laboratory and field test procedures, and guidelines based on the uncertainties associated with gravimetric, volumetric, and master meter test methods.

The accuracy of test standards used to test commercial weighing and measuring equipment is specified in NIST Handbook 44 Appendix A-Fundamental Considerations 3. Testing Apparatus. The Fundamental Considerations specifies that the tolerance for the test standard when used without corrections must be such that its combined error and uncertainty are less than one-third of the applicable device tolerance. When using a correction for a standard, the uncertainty associated with the corrected value must be less than one-third of the applicable device tolerance. The reason for this requirement is to give a device being tested as nearly as practicable the full benefit of its own performance tolerance. Currently there is no NIST Handbook 105-Series standard that specifies the specifications and tolerances for a suitable master meter field standard.

Diane Lee of the NIST Weights and Measures Division (WMD)-Legal Metrology Devices Group and John Wright of the NIST Process Measurements Division (PMD)-Fluid Metrology Group will collaborate to make a preliminary assessment of the uncertainties associated with each test method. John Wright provided a presentation of the three test methods covering the uncertainties associated with each method and the impact that individual factors contribute to the total uncertainty of the measurement. A preliminary matrix (See Appendix F) was reviewed by the DSS outlining the pros and cons of the three test methods addressed in the draft Hydrogen Gas Measuring Device Code. A draft examination procedure outline (See Appendix G) for field inspection and test of a hydrogen dispenser was distributed to the DSS for comment. NIST WMD and PMD staff will continue conducting preliminary analysis of the uncertainties associated with the gravimetric, volumetric, and master meter test methods permitted for use to verify the performance of commercial hydrogen dispensing equipment. This analysis is necessary to determine if adequate testing apparatus is available for each procedure.

The DSS agreed it would be advantageous to multiple stakeholders in the hydrogen community if a single test standard apparatus can be developed for use to verify a dispenser's accuracy. The goal would be to develop a test apparatus that could also be used to determine whether the dispenser's fill protocol can attain the fuel's target density recommended by SAE/CSA and automobile manufacturers and not result in over heating and/or over pressurizing the receiving receptacle/vessel. Micro Motion, Inc. shared data (See Appendix H) with the DSS that demonstrates some of the transients experienced during hydrogen delivery in mass flow metering systems.

The DSS noted that further study will be necessary to determine the effects of (1) pressure and temperature sensors (type and location) and the tank dimensions (volumetric test method), (2) product stratification, (3) condensation (at 70 MPa fill and when empting tanks), (4) leak rate of tanks, (5) characteristics of the master meter, (6) wind and vibration (gravimetric test method), and (7) material composition of the test apparatus storage tank on performance test data.

(b) Opportunity for Reports on Related Activities

(i) Update on Work at CDFA DMS

CDFA has partnered with the California Energy Commission (CEC) and California Fuel Cell Partnership on hydrogen related activities. The CEC has $120M and the California Air Resources Board has $7M to allocate on various hydrogen research projects.

(ii) Update on Work at Other Agencies/Organizations

NIST Process Measurement Division reports funding for a facility to accurately measure transients is underway.

(c) Draft Code

The DSS revisited the Application Section in Draft Version 3.2 of the NIST Handbook 44 Hydrogen Gas Measuring Devices Code (See Appendix B). The DSS requested its Technical Advisor research what is the most appropriate language to include in the application section to ensure a tentative code can be applied to equipment undergoing type evaluation. The tentative code status can last up to five years before there is a permanent code in place for officials to enforce in field applications. This latest version of the draft code was the result of work by the DSS at its August 2008 meeting. The DSS resumed its review of the code in the User Requirements section, where it ended its review in August 2008.

The DSS agreed the changes made to the Draft Code in December 2008 should be forwarded in January 2009 to the NCWM Specifications and Tolerances Committee. This updated code (Draft 3.3) will make the national weights and measures community aware that the USNWG is actively working to fully develop the code with a goal of having a final draft ready by January 2010 for inclusion in NIST Handbook 44. January 2009 will be the first time the draft code appears on a national agenda. Since 1905 the NCWM is the forum whereby national weights and measures standards have been introduced, discussed, and formally recognized by the States.

The DSS had lengthy discussions about (1) the suitability of equipment for use in vehicle refueling applications, (2) ensuring that sales of hydrogen to the end user and other sales transactions are fully addressed in the draft code, and (3) properly addressing multiple factors that may affect the accuracy of measurement. Most notably the DSS identified transient flow, pressures, and temperatures, the minimum measured quantity specified by the OEM, and the dispenser hose length as issues of greatest concern. It is important that no aspect of the weights and measures component in the hydrogen infrastructure is overlooked to avoid hindering the U.S. transition to a hydrogen economy. At this moment, the primary focus of the USNWG is the retail dispenser; however, all methodologies for commercial sales will need to be adequately addressed. Other applications to be addressed include pipeline metering and vehicle tank deliveries, which are considered wholesale applications. These applications must be addressed so that provisions are in place for field enforcement officials. The regulatory authority must have the enforcement tools should for example the unit of measurement be questioned, or a dispute arise over measurement accuracy because of improper connections to receiving vessels, or when practices result in a potential for product loss during a transaction. These applications will need to be examined to determine if the methods being considered are reasonable and sound from a metrological standpoint.

The DSS recognized that the corresponding international document for gaseous hydrogen refueling applications includes requirements for the minimum measured quantity (MMQ) to address the (1) suitability of the equipment for a small delivery; (2) how the MMQ value is expressed and marked on equipment; (3) the relationship of the MMQ value to flow settings; and (4) permissible errors for a minimum delivery under certain operating conditions. In December 2008, the DSS considered the international requirement as it developed design and use paragraphs which specify the minimum measured quantity value in relation to the measuring system's flow rate. The following paragraphs are excerpted from the International Organization for Legal Metrology model regulation 139 for compressed gaseous systems used for vehicle fueling:

OIML R 139 Compressed Gaseous Fuel Measuring Systems for Vehicles (2007) Corresponding Minimum Measured Quantity Definitions and Requirements		
Paragraph	Paragraph Title	
T.3.5	Minimum Measured Quantity of a Measuring System	Smallest mass of gas for which the measurement is metrologically acceptable for that system. Note: This smallest mass is also referred to as the minimum delivery.
2.3.1	Field of Operation; Characteristics	The field of operation of a measuring system is to be specified by the manufacturer and is determined by the following characteristics: ▪ minimum measured quantity, ▪ measuring range limited by the minimum flowrate, Q_{min}, and the maximum flowrate, Q_{max}, ▪ maximum pressure of the gas in the refueling station gas storage, P_{st}, ▪ maximum fast fill pressure of the gas-fuelled vehicle, P_v, ▪ if critical, minimum pressure of the gas, P_{min}, ▪ if appropriate, nature and characteristics of the gases to be measured, ▪ maximum temperature of the gas, T_{max}, ▪ minimum temperature of the gas, T_{min}, ▪ environmental class (see A.2). The maximum and minimum temperatures of the gas are those in the measuring transducer when measuring. The environmental class may be different according to devices of the measuring system, provided each device is used according to its own environmental class. In particular this is applicable to some parts of a self-service device which can be used at different temperatures than the rest of the measuring system.
2.3.2	Field of Operation; Minimum Measured Quantity Form	The minimum measured quantity of a measuring system shall be of the form 1 x 10^n, 2 x 10^n, 5 x 10^n kg, where n is a positive or negative whole

		number, or zero. The minimum measured quantity shall satisfy the conditions of use of the measuring system. Except in exceptional cases, the measuring system shall not be used for measuring quantities less than this minimum measured quantity. Measuring systems having a maximum flowrate not greater than 30 kg/min shall have minimum measured quantity not exceeding 2 kg. Measuring systems having a maximum flowrate larger than 30 kg/min but not greater than 70 kg/min shall have a minimum measured quantity not exceeding 5 kg. Measuring systems having a maximum flowrate greater than 70 kg/min shall have a minimum measured quantity not exceeding 10 kg.
3.1.3	Maximum Permissible Errors (MPEs) and Other Metrological Characteristics; MPE Applicable to the Minimum Measured Quantity	The maximum permissible errors applicable to the minimum measured quantity are twice the corresponding values stated in 3.1.1. So the minimum specified mass deviation (E_{min}) for the measuring system is given by the formula: $E_{min} = 3 \text{ x } M_{min}/100$ Where M_{min} is the minimum measured quantity having the form specified in 2.3.2. Note: The minimum specified mass deviation is an absolute maximum permissible error.
5.2.1	Power Supply Device; Indicated Mass Error	A measuring system shall be provided with an emergency power supply device allowing: ▪ either (a) all measuring functions to be safeguarded during a failure of the principal power supply, ▪ or (b) that data contained at the moment of a failure leading to stopping the flow are saved and displayable on an indicating device subject to legal metrology control for sufficient time to permit the conclusion of the current transaction. The absolute value of the maximum permissible error for the indicated mass, in the second case, is increased by 5 % of the minimum measured quantity.
6.1.7	Technical Requirements for Measuring Systems with Self-service Arrangement; Affect of Scale Interval	In the case of a self-service arrangement that totalizes the delivered mass for different registered customers over the course of time, the minimum measured quantity is not affected by the scale interval used for such totalizations.
7.1.1	Marking; Information	Each measuring system, component or subsystem for

		which type approval has been granted shall bear, placed together legibly and indelibly either on the front face of the indicating device or on a special data plate, the following information: a) type approval sign, b) manufacturer's identification mark or trademark, c) designation selected by the manufacturer, if appropriate, d) serial number and year of manufacture, e) characteristics as defined in 2.3.1 and 4.1.1, f) in relation with Annex B, if the system involves or is (or is not) intended to be used in a service station utilizing a sequential control device, g) where relevant, the maximum allowed speed of switching between banks for the sequential control device (the tested one). Note: The indicated characteristics should be the actual characteristics of use, if they are known when the plate is affixed. When they are not known, the indicated characteristics are those allowed by the type approved certificate. However, the minimum and the maximum temperatures of the gas shall appear on the data plate only when they differ from – 10 ºC and + 50 ºC respectively. The minimum measured quantity of the measuring system shall in all cases be clearly visible on the front face of any indicating device visible to the user during the measurement. When a measuring system can be transported without being dismantled, the markings required for each component may also be combined on a single plate.
8.	Metrological Control; Errors on Indications of Mass	When a text is conducted, the expanded uncertainty on the determination of errors on indications of mass shall be less than one-fifth of the maximum permissible error or tolerance applicable for that test on type approval and one-third of the maximum permissible error applicable for that test on other verifications. The estimation of expanded uncertainty is made according to the Guide to the Expression of Uncertainty in Measurement (1995) with k = 2.

		However, this provision may not be fulfilled for tests at the minimum measured quantity or at twice this value. Note: The expanded uncertainty includes components of uncertainties that are in relation to the instrument to be verified, in particular its scale interval and, if applicable, the periodic variation. However, the repeatability error of the meter or device to be verified shall not be included in the uncertainty. In the case of repeatability tests (not performed in conjunction with accuracy tests), the above ratios apply to the stability of standards. The working standards and their use will be the subject of specific International Documents as far as necessary.
8.3.2.	Subsequent Verification; Test Quantity	The first stage of the verification (of the meter) should only be repeated if the protective marks on the measuring element of the meter have been damaged. This stage may be replaced by a test of the measuring system if the conditions for the first stage of the verification are met and if the measuring system can undergo testing with a delivered gas quantity corresponding to the minimum measured quantity and larger quantities. For the determination of the errors, the maximum flowrate should be reached where possible.
B.2.3	Accuracy Tests Involving Only One Bank	Tests without sequential controls shall be performed in the following conditions: Test 4 Initial test receiver pressure of 0 bar Initial station storage pressure at P_{st} Test 5 Initial test receiver pressure of 0.5 x P_v Initial station storage pressure at P_{st} Test 6 Initial test receiver pressure of 0.75 x P_v Initial station storage pressure at P_{st} Test 7 (minimum measured quantity) The conditions for test 6 are adapted in order to test the minimum measured quantity. For this purpose, the pressure does not have to be P_v in the test receiver at the end, but may be any pressure (as close as practical to P_v)

		such that the quantity of transferred gas shall be at least the minimum measured quantity. For tests without bank switching, the test reservoir pipework can simply be changed so that all test reservoir cylinder banks are joined together, i.e., there are no high, medium or low banks; the reservoir in this case is a uniform station storage pressure system.
Annex B B.2.5	Endurance Test	It is advisable to perform the endurance test on site in real conditions of use. It shall involve at least 5 000 deliveries performed in less than six months. When the endurance test is performed in a laboratory, it consists in performing 5 000 deliveries of gas, representative of the real use and at least involving action of the sequential control device where relevant. The recommended test is test 1 or test 4, depending on whether the measuring system is intended to operate with or without a sequential control device. Note: Some Members have the possibility to authorize instruments subject to type approval to be put into provisional use for some specific tests (after demonstration of a minimum of good performance in laboratory). The measured volume for each delivery shall be 20 times the minimum measured quantity at least and the deliveries may be simulated. After the endurance test, the meter is again subject to the following tests. For meters or measuring systems not using a sequential control device, test 1 shall be performed at least 3 times. For meters or measuring systems not using sequential control device, test 4 shall be performed at least 3 times. The mean value of the corresponding initial intrinsic errors is calculated. The mean value of the corresponding errors after the endurance test is calculated. The deviation between these two values shall remain within the limit specified in 3.1.7. The repeatability shall meet the requirement of 3.1.6.
Annex C Conclusion		In general and except for testing at the minimum measured quantity, it is proposed to perform tests corresponding to cases (1) to (4) on quantities corresponding to at least 1 000 scale intervals and to

		perform tests corresponding to cases (5) and (6) on quantities corresponding to 10 000 scale intervals. However, in case of necessity (long tests) 5 000 scale intervals are sufficient for case (6).
Annex D D.3.1	Low Flow Cut Off	In general, a so called low flow cut off is installed in coriolis meters. This feature prevents flowrates below this value from being a measurement. Values higher than this value are recorded (without subtraction of the low flow cut off value) as a measurement. During testing, in most cases, it is desirable to see all flow indications, even if below the normal low flow cut off value. Therefore, during most performance tests the low flow cut off should be set to zero. For the tests in application of this Annex, the low flow cut off shall be set to zero. In real life situations a value other than zero is needed. Generally, the optimal value in practice depends on the zero-stability of the meter, the minimum measured quantity of the complete measuring instrument and the application itself.

(d) Revisions to the Draft Code
Paragraphs modified by the DSS during the December 2008 meeting and the rationale for their actions are as follows:

<table>
<tr><th colspan="3">December 2008 DSS Modifications to
Draft 3.2 of the NIST Handbook 44 Hydrogen Gas Measuring Devices Code</th></tr>
<tr><td>Change to Requirements: Modified paragraph S.1.3.3</td><td>Requirement Title: Maximum Value of Quantity-Value Divisions</td><td>Reason for Change: Decreased the allowable maximum value for the quantity division. The size of the division shall not exceed a specified percentage of the minimum measured quantity to ensure there is sufficient resolution in the scale interval to avoid introducing further uncertainty in the measurement of small quantities.</td></tr>
<tr><td colspan="3">S.1.3.3. Maximum Value of Quantity-Value Divisions. - The maximum value of the quantity-value division shall be not greater than <s>1.0</s> 0.5 % of the minimum measured quantity.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Change to Requirements: Modified paragraph S.2.1.(a)</td><td>Requirement Title: Return to Zero; primary indicating element</td><td>Reason for Change: Paragraph specifies that it is the intent of the requirement for any primary indicator and recording element of to be capable of returning to zero before start of the next transaction.</td></tr>
</table>

		Note: Paragraph S.2.3. addresses other mass flow meter applications where a nonresettable totalizer is recognized.

S.2.1. Return to Zero.

(a) **~~One~~ The primary indicator and the primary recording elements, if the device is equipped to record, shall be provided with a means for readily returning the indication to zero either automatically or manually.**

(b) **It shall not be possible to return primary indicating elements, or primary recording elements, beyond the correct zero position.**

Change to Requirements: Added new paragraph S.8.	Requirement Title: Minimum Measured Quantity	Reason for Change: Added design requirements that further clarify a suitable size for a minimum delivery relative to the flow rate conditions that exist when the system is in operation so that the equipment's performance can be verified based on Handbook 44 test standard criteria. (Note: the format for the relationship of the MMQ is taken from OIML R 139 para. 2.3.2)

S.8 Minimum Measured Quantity.

The minimum measured quantity shall satisfy the conditions of use of the measuring system as follows:

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

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

Change to Requirements: Modified paragraph UR.1.1.	Requirement Title: Computing-Type Device, Retail Dispensers	Reason for Change: Added text to paragraph title to clarify that in a retail application it is the dispenser that is used to refuel vehicles that must provide transaction information, whereas, in a sale to other than the end user (wholesale application) an invoice may be sufficient.

UR.1.1. Computing-Type Device, Retail Dispensers. – A hydrogen gas dispenser used to refuel ~~in a commercial sale application~~ vehicles shall be of the computing type and shall indicate the mass, the unit price, and the total price of each delivery.

Change to Requirements: Modified paragraph UR.1.2.	Requirement Title: Discharge Hose-Length	Reason for Change: Language taken from corresponding codes that apply to retail fueling dispensers to ensure the hose length is sufficient to reach the receiving vessel and does not have a detrimental effect on the delivery of metered product.

UR.1.2. Discharge Hose-Length. - The length of the discharge hose on a retail fuel ~~device~~ dispenser:

(a) shall not exceed 4.6 m (15 ft) unless it can be demonstrated that a longer hose is essential to permit deliveries to be made to receiving vehicles or vessels~~.~~;

~~The hose length~~

(b) shall be measured from its housing or outlet of the discharge line to the inlet of the discharge nozzle~~.~~; and

~~The hose~~

(c) shall be measured with the hose fully extended if it is coiled or otherwise retained or connected inside a housing.

An unnecessarily remote location of a device shall not be accepted as justification for an abnormally long hose.

Change to Requirements: Added new paragraph UR.1.3.(c)	Requirement Title: Minimum Measured Quantity; Maximum Flow Rate	Reason for Change: Added user requirements that further clarify that the user should not operate the system outside of the minimum delivery intended by the manufacturer. This new paragraph corresponds to the design requirement in paragraph S.8.

UR.1.3. Minimum Measured Quantity

:

(c) The minimum measured quantity shall satisfy the conditions of use of the measuring system as follows:

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

(2) Measuring systems having a maximum flowrate not greater than 4 kg/min but not greater than 12 kg/min shall have a minimum measured quantity not exceeding 1.0 kg.

Change to Requirements: Modified term in the title of paragraph UR. 2.3.	Requirement Title: Low-Flow Cut-Off	Reason for Change: Deleted the term "valve" and replaced it with the term "value" since the intent of the requirement is to prohibit the installer or operator from using the system below the minimum flow rate value specified by the manufacturer, because the equipment may not be designed to accurately measure at this low flow.

UR. 2.3. Low-Flow Cut-Off ~~Valve~~ Value. – If a metering system is equipped with a programmable or adjustable "low-flow cut-off" feature:

(a) the low-flow cut-off value shall not be set at flow rates lower than the minimum operating flow rate specified by the manufacturer on the meter; and

(b) the system shall be equipped with flow control valves which prevent the flow of product and stop the indicator from registering product flow whenever the product flow rate is less than the low-flow cut-off value.

Change to Requirements: Modified title of paragraph UR.3.4.	Requirement Title: Ticket in Printing Device; Vehicle-mounted Metering Systems	Reason for Change: Added text to title paragraph to clarify the requirement applies to meters mounted on trucks and similar applications where there might be the potential to ride on a single ticket that could be used to charge one customer for a delivery to a previous customer(s).

UR.3.4. Ticket in Printing Device; Vehicle-mounted Metering Systems. - A ticket shall not be inserted into a device equipped with a ticket printer until immediately before a delivery is begun, and in no case shall a ticket be in the device when the vehicle is in motion while on a public street, highway, or thoroughfare.

Change to Requirements: Modified paragraph UR.3.5.	Requirement Title: Steps After Dispensing	Reason for Change: Added text to the requirement to recognize that hydrogen may be delivered as a source of energy to other than motorized vehicles and to acknowledge an additional mechanism that the operator may

<table>
<tr><td></td><td></td><td>use to engage the zero before the start of the next transaction.</td></tr>
<tr><td colspan="3">UR.3.5. Steps After Dispensing. - After delivery to a customer from a retail ~~motor-fuel device~~ dispenser:

(a) the device shall be shut-off at the end of a delivery, through an automatic interlock that prevents a subsequent delivery until the indicating elements and recording elements, if the device is equipped and activated to record, have been returned to their zero positions; and

(b) the discharge nozzle shall not be returned to its start position unless the zero set-back interlock is engaged or becomes engaged by the act of disconnecting the nozzle or the act of returning the discharge nozzle.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Change to Requirements: Deleted text from paragraph UR.3.6.</td><td>Requirement Title: Return of Indicating and Recording Elements to Zero</td><td>Reason for Change: Deleted antiquated text which applied to older equipment since newer equipment is required to be returnable to zero in paragraph S.2.1. Return to Zero.</td></tr>
<tr><td colspan="3">UR.3.6. Return of Indicating and Recording Elements to Zero. - The primary indicating elements (visual), and the primary recording elements ~~when these are returnable to zero,~~ shall be returned to zero immediately before each delivery. ~~Exceptions to this requirement are totalizers on key-lock-operated or other self-operated dispensers and the primary recording element if the device is equipped to record~~.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Change to Requirements: Modified paragraph UR.3.8.</td><td>Requirement Title: Conversion Factors</td><td>Reason for Change: Modified the paragraph designation to cite the appropriate reference information. Modified the term "conversion" to correctly specify that it is "correction" values that are applied to adjust the measurement for influence factors.</td></tr>
<tr><td colspan="3">UR.3.8. Conversion Factors. – Established ~~conversion~~ correction values (see references in N.~~8~~7.) shall be used whenever metered hydrogen gas is billed. All sales shall be based on kilograms.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Change to Requirements: Modified the definition for minimum measured quantity</td><td>Requirement Title: Minimum Measured Quantity</td><td>Reason for Change: Modified the text to clarify the conditions that apply to the delivery.</td></tr>
<tr><td colspan="3">minimum measured quantity (MMQ). The smallest quantity delivered for which the measurement is ~~accurate~~ to within the applicable tolerances for that system . . . 3.37,</td></tr>
</table>

<u>3.3X]</u>

(4) Next Steps/Tasks
At the conclusion of the meeting, the USNWG agreed that the next two meetings will be tele- and web-conferences, while an April and August in-person meeting should also take place in 2009. The USNWG Subcommittees identified the meeting dates that are listed in the table in Item (5). 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 continue to be based on logistics and technical tasks that the USNWG must accomplish. A target date of January 2010 was identified for having a final code ready for national review and approval.

(5) Next Meeting
At the conclusion of the December 2008 meeting the DSS had a better understanding of future work that is needed to develop hydrogen measurement standards and test procedures. The USNWG will continue to 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. Tentative sites for the April and August 2009 meetings are: (1) NIST-Gaithersburg, MD, (2) Palm Springs, CA , (3) Grand Forks, North Dakota, (4) Santa Monica, CA.

Schedule for the USNWG 2009 Meetings	
Date(s)	**Location**
January 30, 2009/1:00 p.m. - 3:00 p.m. EST	Tele/Web Conference Meeting
February 24, 2009/1:00 p.m. - 3:00 p.m. EST	Tele/Web Conference Meeting
April 28-30, 2009 /Day1&2 8:30 a.m. – 5:00 p.m. EDT DSS Meeting; Day 3 8:30 a.m. – 12 noon EDT FSS Meeting	In-Person Meeting TBD
August 18-20, 2009 /Day1&2 8:30 a.m. – 5:00 p.m. EDT DSS Meeting; Day 3 8:30 a.m. – 12 noon EDT FSS Meeting	In-Person Meeting TBD

(6) USNWG-Technology Tours
The USNWG had multiple opportunities to observe related work being conducted at NIST, the National Renewable Energy Laboratory (NREL) National Wind Technology Center (NWTC), and MicroMotion, Inc. in Boulder, Colorado.

(a) MicroMotion, Inc.
During its tour of MicroMotion, Inc., the USNWG gathered information about the coriolis mass flow meter technology that many OEMs currently use to meter hydrogen in their refueling dispensers. The tour included the manufacturing floor and proving areas.

(b) NIST Boulder, CO
NIST-Boulder Thermophysical Properties Division and Materials Reliability Division provided an overview of the cryogenic flow facility, ongoing work on thermal conductivity measurement and density metrology, and hydrogen's effect on pipelines and storage vessels, respectively. The work at NIST is critical to original equipment manufacturers (OEMs), laboratories, and officials. These entities must consider the effects of operational conditions and the thermophysical properties of hydrogen on measurements, the durability, suitability, and safety of equipment, components, test standard apparatus, and storage vessels for use/test of equipment in commercial applications. The draft code under development by the USNWG for hydrogen dispensing equipment references the NIST Chemistry

WebBook, NIST Standard Reference Database 23, and other publications as sources of thermophysical property information for hydrogen that apply in density calculations.

(c) NREL-Wind to Hydrogen (Wind2H2) Project

The NREL NWTC Wind to Hydrogen (Wind2H2) Project provided the USNWG with an opportunity to observe hydrogen production and delivery systems research. The Wind2H2 Project links wind turbines to electrolyzers which produce hydrogen from water. The project recently took possession of a fuel cell vehicle and is in the process of installing a gaseous hydrogen dispenser for refueling the vehicle. The dispenser is similar to the type that will operate in publicly accessible service stations and must ultimately comply with the design, performance, fuel quality, and methods of sale requirements under development by the USNWG.

The USNWG wishes to express its deepest appreciation to Micro Motion, Inc., NIST Boulder, and the NREL Wind to Hydrogen Project for this learning experience.

FUEL STANDARDS SUBCOMMITTEE (FSS) MEETING
Thursday, December 4, 2008, 8:30 a.m. – 12 noon (MT)
MicroMotion, Inc., 7070 Winchester Circle
Boulder, CO
Chair – Robert "Bob" Boyd (Linde, Inc)
Technical Advisor –Lisa Warfield (NIST WMD)

(1) Welcome and Introductions

After a weather delay, the FSS participants were welcomed in-person 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 MicroMotion, Inc., 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 discussed and decided on procedures for managing and documenting its technical work. The following items were addressed:

(a) Approve the Summary of the August 2008 USNWG Meeting

The FSS acknowledged that where applicable all paragraphs should be modified throughout the summaries to clarify that although there is no final fuel quality standard published by a nationally recognized standards body, the USNWG Subcommittees are moving forward with an interim standard.

The USNWG agreed to approve the August 2008 meeting summary (See Appendix A) with the aforementioned modifications. USNWG meeting minutes are available on the NIST Weights and Measures web site at http://www.nist.gov/owm.

(b) Change in NIST Technical Advisor to the Subcommittee

Effective October 1, 2008, Lisa Warfield, NIST WMD Laws and Metrics Group assumed responsibility as the NIST Technical Advisor to the Fuel Specifications Subcommittee from Ken Butcher (NIST WMD).

(c) Approve the USNWG Guidelines

A draft of the Guidelines incorporating the USNWG's comments from June 2008 and associated Agenda Submission Form were distributed on August 17, 2008 to the USNWG. During the August 26-27, 2008 meeting the USNWG agreed that the Technical Advisor should ballot the USNWG for its approval of the Guidelines and Agenda Submission Form due to time constraints.

During the December 2008 meeting, the DSS requested that the Technical Advisor redistribute the August 2008 version of the guidelines by December 9, 2008 and ballot the subcommittee by email for its approval. The DSS should complete its review and return their comments and vote to the Technical Advisor by January 9, 2009. Members agreed that in instances where a member does not respond by the deadline, then that particular vote will count in favor of the guidelines and form. January 21 became the new deadline for voting results.

(3) Method of Sale for Hydrogen Dispensing Applications
The FSS continues its work to develop appropriate method of sale requirements based on Draft Version 2.2 (see Appendix C) of the Uniform Laws and Regulations. This version includes modifications recommended in August 2008 by the FSS.

The FSS also has under its review 16 CFR Part 309 "Labeling Requirements for Alternative Fuels and Alternative Fueled Vehicles," (see Appendix D), which includes the FTC requirements for posting the hydrogen fuel rating on dispensers. This labeling requirement specifies that a disclosure of the amount of the principal component of a fuel is expressed as a minimum percentage on a label in a fashion similar to what is now required in octane posting for gasoline pumps. The FSS discussed further amending Handbook 130 to address this requirement.

The FSS agreed to modify the proposal for NIST Handbook 130 Laws and Regulations and Engine Fuel Quality to include a retail dispenser labeling requirement that addresses the FTC requirement for posting the principal component of hydrogen fuel. The FSS agreed to add new paragraph 2.XX.3.5 to read:

2.XX.3. Retail Dispenser Labeling.

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

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

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

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

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

Ron Hayes (MO Dept. of Ag.) will get clarification on the significant number of whole digits required to the right of the decimal point. Several members of the FSS question whether or not this number is confusing since it does not reflect which constituents may be present and the variation of impurities that may be present as a result of the feedstock. The current proposal specifies the minimum value for the hydrogen fuel index as 99.97, which is the value obtained with the value of total gases (%) subtracted from 100 %.
The goal is to reach a consensus on a specification that is not too restrictive and does no harm to fuel cell vehicles.

(a) Opportunity for Reports on Related Activities

(i) Update on Work at CDFA DMS
(ii) Update on Work at Other Agencies/Organizations

(4) Engine Fuel Quality
The USNWG Fuel Specification Subcommittee (FSS) agreed to recommend that the weights and measures community consider a proposal for a hydrogen fuel quality standard (See Appendix C) which is the same as the interim standard adopted in September 2008 by the State of California. The interim standard is a starting point until a national or international standards body recognizes this or another standard. This FSS proposal was distributed for the first time for national review by the weights and measures community at the January 2009 NCWM Interim Meeting. The FSS discussed the ability of laboratories to measure all of the constituents specified in the fuel standard and the need for fuel quality laboratories to have standard reference materials. The FSS has proposed one fuel quality standard for both internal combustion engine and fuel cell vehicles. The FSS is considering a procedure that might allow officials/laboratories to simultaneously sample for quantity and quality in part because this method may lessen the likelihood of contaminating the sample.

California Division of Measurement Standards explained its mandate and the process it followed to have a hydrogen fuel quality standard.

(a) Opportunity for Reports on Related Activities
The task force is working on determining what gas is present at the dispenser. University laboratories are also working to determine the effects on single fuel cell applications. There is some concern the ISO standard may have immeasurable constituent levels and this standard is currently on a fastrack.

(5) Laboratory Manual
The FSS discussed ongoing work to ensure fuel quality laboratories perform measurements that are traceable to recognized national standards.

(a) Opportunity for Reports on Related Activities
ASTM-The FSS was updated on the work by ASTM D02 to develop a set of safety practices for laboratories.

CSA-CSA America is planning an outreach effort for 2009 to solicit input from states that have multiple responsibilities. The CSA will focus on the area of safety in an effort to help agencies avoid duplicating their efforts. CSA HGV 4.9 "Interim Hydrogen Fueling Station Safety Guideline" will be ready for review by the end of December 2008 and a Technical Information Report is projected for Summer 2009.

(b) Laboratory Practices and Procedures
There is work currently underway to develop a series of procedures using advance test methods such as gas chromatograph and mass spectroscopy.

The FSS will work to promote the establishment of documented laboratory practices and procedures that encompass:

(i) Test Methods and Reproducibility Limits

(ii) Equipment (minimum and recommended) Source and Cost
(iii) Documentation (e.g., Standard Operating Procedures)
(iv) Handling and Storage of Hydrogen Fuel
(v) References and Good Laboratory Practices
(vi) Minimum Training Standards for Laboratory Personnel
(vii) Facilities
(viii) Safety

(6) Field Sampling Procedures
The FSS briefly discussed 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 four areas listed in subparagraph (b).

(a) Opportunity for Reports on Related Activities
ASTM-ASTM D03.14 has given priority to sampling method for high pressure gas.

(b) Procedures/Guidelines

(i) Equipment/Source/Cost
(ii) Good Sampling Practice
(iii) Handling, Storage, and Transportation
(iv) Minimum Training Standards for Field Officials

(7) Next Steps/Tasks

(8) Next Meeting
At the conclusion of the December 2008 meeting the FSS had a better understanding of future work that is needed to develop hydrogen measurement standards and test procedures. Some tasks may be completed by conference calls and email, while others may require an in-person meeting of the FSS. The USNWG Subcommittees identified the dates listed in the table below for upcoming USNWG meetings. 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. Tentative sites for the April and August 2009 meetings are: (1) NIST-Gaithersburg, MD, (2) Palm Springs, CA , (3) Grand Forks, North Dakota, (4) Santa Monica, CA.

Schedule for the USNWG 2009 Meetings	
Date(s)	**Location**
January 30, 2009/1:00 p.m. - 3:00 p.m. EST	Tele/Web Conference Meeting
February 24, 2009/1:00 p.m. - 3:00 p.m. EST	Tele/Web Conference Meeting
April 28-30, 2009 /Day1&2 8:30 a.m. – 5:00 p.m. EDT DSS Meeting; Day 3 8:30 a.m. – 12 noon EDT FSS Meeting	In-Person Meeting TBD
August 18-20, 2009 /Day1&2 8:30 a.m. – 5:00 p.m. EDT DSS Meeting; Day 3 8:30 a.m. – 12 noon EDT FSS Meeting	In-Person Meeting TBD

Appendix I

Attendee List-December 2-4, 2008
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 Yes (Y)	Attended FSS Yes (Y)
Chad Blake	NREL-Hydrogen Technologies and Systems Ctr.	Y	Y		Y
Robert Boyd	Hydrogen Solutions – Linde Group	Y	Y	Y	Y
Tina Butcher	NIST – TS WMD	Y	Y	Y	Y
Marc Buttler	Micro Motion/Emerson Process Management	Y	Y	Y	Y
Julie Cairns	CSA America	Y	Y	Y	Y
Joseph Cohen	Air Products and Chemicals, Inc.	Y	Y	Y	
Ronald Hayes	Missouri Dept. of Agric.-Weights and Measures Div.		Y		Y
Jared Hightower	Greenfield Compression	Y	Y	Y	Y
Robert Ingram	CA – Food and Ag., Div. of Measurement Standards	Y	Y	Y	Y
Michael Keilty	Endress &	Y	Y	Y	Y

	Hauser Flowtec AG				
Kristin Macey	CA – Food and Agriculture, Division of Measurement Standards	Y	Y	Y	Y
Dev Patel	Kraus Global	Y	Y	Y	Y
Kenneth Ramsburg	MD Dept of Agriculture, Weights and Measures Program	Y	Y	Y	
Juana Williams	NIST – TS WMD	Y	Y	Y	Y
John Wright	NIST Chemical Science and Technology Laboratory, Process Measurements Division	Y	Y	Y	

Appendix I			
Guest List-December 2-4, 2008 **USNWG Hydrogen Device Standards and Fuel Specifications Subcommittees**			
Name	Agency	Attended DSS Yes (Y)	Attended FSS Yes (Y)
Christine Manchester	Regulatory Logic	Y	Y
James Merritt	USDOT-Office of Pipeline Safety	Y	
Gary Nakarado	Regulatory Logic	Y	Y
Carl Rivkin	NREL-Hydrogen Technologies and Systems Ctr.		Y