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

October 3-4, 2007
National Institute of Standards and Technology (NIST)
Weights and Measures Division (WMD)
Gaithersburg, Maryland

MEETING SUMMARY

This meeting was sponsored by the U.S. Department of Energy (DOE) and U.S. Department of Commerce's National Institute of Standards and Technology.

Purpose: The U.S. National Work Group (USNWG) met in its first in-person meeting to continue work to establish 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.

AGENDA ITEMS

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*** NOTE:** Appendices A through Q to the Meeting Summary are listed on page 2. Appendices A-O are in PDF format and available on request.

Attachments List		
Appendix	**Related Agenda Item(s)**	**Title**
A	7	Comments from U.S. Stakeholders on the 1st Draft of the NIST Handbook 44 Hydrogen Gas Meters Code (2005)
B	7	Comments on the 2nd Draft of the NIST Handbook 44 Hydrogen Gas Meters Code (27Sep07) – Buttler (Micro Motion)
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E	7	Draft 2.1 NIST Handbook 44 Section 3.3X Hydrogen Gas Meters Code (03Oct2007)
F	2	EPO No. 28 "Compressed Natural Gas Retail Motor-Fuel Dispensers"
G	7	Hydrogen Gas Flow Standard with Transient Conditions (06Aug07) – Wright (NIST)
H	7	NBS Handbook 145 "Handbook for the Quality Assurance of Metrological Measurements SOP 2 Recommended Standard Operations Procedures for Applying Air Buoyancy Corrections (2003)
I	2	NIST Handbook 130 Excerpts from the "Uniform Engine Fuels, Petroleum Products, and Automotive Lubricants Regulation" (2008)
J	7	OIML International Document 28 "Conventional Value of the Result of Weighing in Air (2004)
K	6	OIML Draft Recommendation "Compressed Gaseous Fuel Measuring Systems for Vehicles" (2007)
L	6	OIML International Recommendation 81 "Dynamic Measuring Devices and Systems for Cryogenic Liquids (1998)
M	2	Update on H2 QA Sample Apparatus Development at Pacific Spirit Station (04Oct07) – Boyd (Linde Gas)
N	2	Standards Practices for Sampling of Particulates in High Pressure Hydrogen and Related Fuel Cell Feed Gases (04Oct07) – Boyd (Linde Gas)
O	1-8	USNWG October 3-4, 2007 Slides – "Welcome," "New Items for the Current and/or Future Agendas," "Weights and Measures in the United States," "NIST Weights and Measures Division Long Range Plan," "What Are the Goals of the Work Group?" "National and International Standards for Hydrogen Measurement," "Development of Standards for Commercial Hydrogen Measurement," "Next Steps," and "Future Meetings"
P		Glossary of Terms and Publications
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Wednesday-Thursday, October 3-4, 2007, 9:00 a.m. – 5:00 p.m. (EST)
NIST, 100 Bureau Drive, Gaithersburg, MD 20899
Building 101, Lecture Room A
Moderator – Juana Williams (NIST)

(1) Welcome and Introductions

The Moderator Juana Williams, NIST Weights and Measures Division, welcomed the participants in-person and on audio conference, called the meeting to order, and covered its purpose (see Item 5). The Moderator also recognized the collaborative work of the U.S. DOE and NIST in sponsoring this meeting. Participants were briefed on the facilities available at NIST, Gaithersburg, a schedule of events, meeting procedures, and materials. Each participant provided their name, affiliation, and stated their specific area of interest in the work to develop hydrogen measurement standards.

Dr. Robert Watters, Jr., Chief NIST TS Measurement Services Division, provided an overview of NIST's mission and its past and current hydrogen projects. NIST's mission is to promote U.S. innovation and industrial competitiveness by advancing measurement science, standards, and technology in ways that enhance economic security and improve the U.S. quality of life. NIST is staffed with over 5000 employees in its technology, quality, laboratories, and services programs at its Maryland and Colorado campuses and other collaborating facilities. NIST has two new programs aimed at converting technology discoveries to products to meet the emerging needs for measurement science and instrumentation in the areas of nanotechnology and neutron research.

In the Early 1950's NIST began work on large scale hydrogen liquefication in support of weapons work at Los Alamos National Laboratories. In the 1960's NIST worked on compiling critical thermodynamic data in support of the Atomic Energy Commission and the National Aeronautics and Space Administration. Most recently NIST provided a new standardized equation for hydrogen gas densities to the Environmental Protection Agency for use in determining fuel consumption and driving ranges for hydrogen fueled vehicles. NIST is also working on the effects of dimensional variations in fuel cell components as well as other methods to test and evaluate fuel cell performance. In addition to the DOE/NIST sponsored USNWG, there are other NIST programs collaborating with external agencies to work on standards and test procedures to assess the performance of hydrogen- metering technologies, pipelines and in related areas of safety and stationery power sources.

(2) New Items for the Current and/or Future Agendas

Participants provided input on topics of technical merit that should be immediately addressed or considered early in the standards development process. In addition to items already on the agenda the participants identified four topics for preliminary discussions. The USNWG agreed to a tentative course of action as outlined below for developing standards to address: (1) units of measurement, (2) blended and other product types, (3) fuel quality specifications, and (4) sampling and test methods.

(a) Units of Measurement

The USNWG agreed that the kilogram is the most appropriate unit of measurement for dispensing, displaying, and recording the amount of product delivered by retail motor-fuel equipment. The USNWG considered this unit from a customer and technical standpoint. Drivers would be able to relate to this unit even though they were used to deliveries of other motor-fuels in gallons. The energy content of a kilogram of hydrogen is near that derived from one gallon of gasoline. Many of the hydrogen dispensers currently in use are equipped with mass flow meter technology and register the amount of measured product in mass units.

The USNWG acknowledged that the Gasoline Liter Equivalent (GLE) or Gasoline Gallon Equivalent (GGE) is the required unit of measurement when compressed natural gas (CNG) is dispensed as an engine fuel even though a separate mass indication must be available for inspection and test of that equipment. The GGE was permitted in part to facilitate the acceptance of the alternative fuel, CNG, by drivers who were used to filling their tanks with gasoline and diesel motor-fuel in gallon increments. The gaseous hydrogen application has many similarities to CNG that eliminates reinventing some requirements. However, one requirement that needs more scrutiny and is the source of complaints to weights and measures officials is the 5.660 lb. of CNG/gal conversion factor used to convert pounds of CNG measured by the meter to a volume displays in GGEs. The use of a single conversion factor introduces uncertainties in measurements because it does not account for the differences in product composition throughout the measurement process or regional supplies. The USNWG considered the cubic foot; a unit of volume recognized for deliveries from hydrocarbon gas vapor-measuring devices as a possible unit of measurement for hydrogen, but opposed this unit because the value assigned to the cubic foot varies among standards bodies.

(b) Hydrogen Blends and Other Forms of Hydrogen

The USNWG is aware that dispensers are in use for delivery of various blended hydrogen motor-fuels as well as hydrogen in both the gaseous and liquid state. Legal metrology standards are in place in other motor-fuel applications where blend ratios must be factored into meter calibration adjustments and settings and are the basis for the advertised and the computed price of a commodity. Additional performance testing and metrological security features can be necessary when blend ratios affect accuracy. Method of sale requirements may be needed to ensure that product quality is not misrepresented and consumers can make value comparisons of products offered for sale from service stations.

Most blended products contain substantial amounts of hydrocarbons such as CNG. The USNWG agreed that hydrogen-CNG blends that contain 20 % or less hydrogen should not be addressed as part of the Draft Hydrogen Gas Meters Code and should, instead, be considered part of the codes that apply to CNG applications. It was noted that motor-fuels with a higher hydrogen composition also require significant changes to vehicle engines.

Initially, the USNWG will address requirements for gaseous hydrogen applications, unless it hears there is an urgency to simultaneously work on standards for hydrogen dispensed in the liquid state. The USNWG agreed to this approach because of the predominance of gaseous hydrogen dispensers in use to fuel prototype vehicles and the gas metering technology is further along in its development. Until weights and measure codes are either modified or adopted specifically for both applications, many of the existing NIST Handbook 44 General Code, Liquid Measuring Devices, Cryogenic Liquid Measuring Devices, and/or Mass Flow Meters Code requirements would apply on an ad hoc basis.

(c) Fuel Quality Specifications

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 individuals participating in Standards and Code Developing Organizations such as the Society of Automotive Engineers, International (SAE), American Society of Testing and Materials, etc. The USNWG will not change that process nor develop the fuel quality standard, but will eventually recommend a quality standard (definition, specifications, and method of sale) that is most appropriate to cite 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 adopting given models then establish and administer programs that monitor and enforce method of sale and fuel specification laws. As an example of standards that need to be developed for hydrogen, the USNWG was provided with corresponding NIST Handbook 130 requirements for compressed natural gas, a similar motor-

fuel application, (see Attachment I).

Work is under way within the global hydrogen community to establish fuel specifications, sampling procedures, and identify test equipment to determine acceptable levels of contaminants, other elements, and particulates for hydrogen refueling applications. The USNWG discussed ongoing work by the International Organization for Standardization (ISO) Technical Committee 197 Working Group 12, California Department of Food and Agriculture Division of Measurement Standards (DMS), and the SAE under its Standard J 2719 working on a technical information report on developing hydrogen fuel specifications. The SAE report and ISO standards are in the draft stage, whereas the DMS standard is out for comment. California mandated that a specification for hydrogen used in internal combustion engines and fuel cell vehicles be established by January 1, 2008. Research is ongoing to determine if it is feasible for products to meet projected specifications and for laboratories to perform measurements to proposed standards.

The USNWG received updates on work by the National Research Council Canada and the Linde Group to develop hydrogen quality sampling procedures (see Attachments M and N). The sources of contaminants such as the environment, motor-fuel dispensing system, sampling methods/equipment, and/or feedstock may need to be factored into test procedures and further analyzed to determine if they are skewing sampling test results. Additional constituents to be considered are the effects of condensation and precipitation that result from phase changes.

Some in the weights and measures community have considered hydrogen to be a pure product; however, there are numerous factors that can affect the purity level of hydrogen such as storage, piping, feedstock, etc. The allowable purity level of hydrogen is not only a concern for fuel cell performance and longevity but may affect meter accuracy depending on the technology. Several members of the USNWG are recommending an approach that sets the limits for hydrogen fuel purity on a percentage basis (for example, 99.999 %, 99.99 %, 99.97 %, or 99.9 % hydrogen). The USNWG briefly discussed constituents most likely to be contaminants, their molecular weight, and the effect of those impurities on hydrogen fuel density. This would bring into question whether or not a mass measurement represents pure hydrogen or a product that has impurities. The USNWG considered the affect of the heaviest contaminant, Argon, on product density even though Helium is the mostly likely contaminant. Impurities up to 0.03 % would not have a significant affect. Therefore, the USNWG agreed that products having a percentage value of 99.97 % for hydrogen would be acceptable.

(d) Sampling and Test Methods

There are two separate tests the USNWG anticipates will need to be performed by weights and measures and fuel quality officials. The first is an accuracy test of the dispenser system and the second is sampling hydrogen for compliance with quality specifications.

The USNWG briefly reviewed the Examination Procedure Outline developed for inspection and test of CNG dispensing systems (see Attachment F). The USNWG discussed some of the uncertainties introduced into the process if the same gravimetric test method used to verify the performance of CNG dispensers is also used to test hydrogen dispenser accuracy. The proposed performance tolerance for commercial hydrogen dispensers is ±1.5 % for type evaluation and new equipment and ± 2.0 % for equipment already in use. NIST Handbook 44 Appendix A Fundamental Considerations Section 3.2. Tolerances for Standards specifies use of standards with an accuracy one-third that of the equipment under test (0.5 %). Hydrogen is six times lighter than CNG so the test draft size will be smaller. However, the receiving tank used as part of the test to simulate a refueling delivery is larger and reinforced more than tanks used to simulate CNG deliveries. Consequently, the test standard (reference scale) must have sufficient capacity to weigh the tank and hydrogen as well as have a high resolution so that its scale division size is not contributing significant errors in the measurement of hydrogen. Additionally, field officials may encounter environmental factors such as wind which make it difficult to make measurements on a reference scale with high resolution. All these issues must be considered when weighing too

light of a test load because these factors are more likely to result in large errors in the weighment. Several members of the USNWG recommend using a test method that uses instrumentation to monitor fill pressures and temperatures and the receiving vessel volume to calculate mass. The USNWG agreed that accuracy is of utmost importance regardless of the test draft size.

General Conclusion:
The USNWG considered it critical to verify dispenser system accuracy and hydrogen fuel quality, at some point it may be determined that quality also affects accuracy of meter technology. The determination of acceptable test methods is essential to the ability to verify commercial hydrogen measurements and will hinge on the latest analytical research data on test methods and standards. The establishment of proper test methods is key to instilling confidence in commercial measurements in this sector of the hydrogen economy. Therefore the USNWG recommends simultaneous work should be carried out to develop equipment standards, test procedures, and fuel specifications. The USNWG agreed that work should be carried out by at least two subcommittees: one to address equipment design, use, and test procedures, and the other should address all aspects of fuel specification requirements. All members of the USWNG will participate on the fuel subcommittee.

(3) Weights and Measures in the United States – Background and History

Participants were briefed on the history of weights and measures standards in the United States. The USNWG was provided with an overview of the structure of U.S. Weights and Measures Regulatory Community and the role of NIST. The standards developed by the USNWG, once adopted as law and regulation by the States, are intended to be the basis for criteria used to approve equipment for commercial use and will be enforced by State and local weights and measures officials who regulate commercial weighing and measuring equipment. Participants were also briefed on the standards development process.

Since 1905, NIST WMD has worked to fulfill its congressional mandate to fix the standards of weights and measures. NIST WMD works with State and local regulatory officials and weights and measures laboratory programs, industry, and consumer groups as technical advisors, coordinating and underwriting the development of comprehensive legal standards that are the basis for equipment performance and use, fuel quality, and methods of sale when commodities are bought and sold based on weight or measure.

The weights and measures standards development process starts with the submission of a well developed proposal to a regional weights and measures association, National Type Evaluation Technical Committee, Task Force, or U.S. National Work Group for review and support. Items supported by one or more of these groups are submitted to a national technical committee such as the Specifications and Tolerances Committee by November 1. The national technical committee may then recommend adoption of the proposal by July the following year at the National Conference on Weights and Measures. While it is only necessary to submit a proposal to one of these groups to initiate the process, authors of proposals are encouraged to circulate a proposal among corresponding associations and/or committees to allow widespread exposure and review of this information by all stakeholders.

The final stage for an adopted standard occurs when it is published as a handbook requirement and subsequently enforced by field officials after the States legislatively adopt handbook requirements as law. The last step in this cycle occurs when technical committees use handbook requirements as the basis for policies or test procedures. Once those policies/procedures are developed they are published and equipment manufacturers must comply with these test criteria before devices are approved for commercial use.

Weights and measures laws and regulations typically affect the every day lives of most U.S. citizens and businesses. Weights and measures roles and responsibilities in commercial measurements ensure there is an unbroken chain so that measurements are traceable where accuracy starts at the international standards level on through to the commercial marketplace where commodities are bought and sold by weight or measure. Weights and measures promote uniform requirements and practices to ensure consumers get what they pay for and businesses receive fair payment for goods or services, thereby leveling the playing field in the marketplace. Additionally, weights and measures works to harmonize national and international standards to lessen trade barriers and promote U.S. commerce.

(4) The NIST Weights and Measures Division (WMD) Long Range Plan

The USNWG was briefed on the NIST WMD plans to carry out its mission to promote uniformity in weights and measures standards and practices to facilitate trade, technology development, and weights and measures requirements and procedures, both nationally and internationally in support of the hydrogen economy. NIST WMD has developed a long range plan to accomplish its goals to promote the development and implementation of commercial hydrogen measurement standards, thereby facilitating the United States transition to a hydrogen economy.

The American Competiveness Initiative and DOE funding NIST WMD received in 2007 now allows expansion and acceleration of WMDs efforts to promote the development of measurement standards for commercial hydrogen refueling dispensers beyond the Draft Hydrogen Gas Meters Code it developed and distributed in 2005. NIST WMD plans over a five year period (2008-2012) to work with stakeholders in technical work sessions and other forums to develop commercial hydrogen measurement standards to address: (1) equipment performance codes; (2) method of sale requirements; (3) labeling and marking requirements; (4) fuel quality standards, sampling and testing procedures; (5) inspection procedures for equipment suitability and safety; (6) training of officials and service companies; and (7) education of all stakeholders on hydrogen measurement. These standards ensure the accuracy of commercial hydrogen measurements, enhance consumer protection, foster fair competition, and facilitate economic growth and trade. The NIST WMD efforts in support of the work to develop commercial hydrogen measurement standards are as follows:

NIST WMD 2004-2007
Since 2004 WMD staff member Juana Williams has been a member of the National Hydrogen and Fuel Cell Codes and Standards Coordinating Committee (NHFCCSCC) and continues to participate in this work. The NHFCCSCC is a committee sponsored by the DOE, National Hydrogen Association, and U.S. Fuel Cell Council coordinating public and private organizations in the development and implementation of hydrogen-related codes and standards for the safe production, delivery and use of hydrogen. The NHFCCSCC plans to promote and share information with other national and international agencies involved in similar work in support of a viable global hydrogen infrastructure. NIST WMD is taking a lead role in promoting the development of legal metrology standards for hydrogen refueling equipment as a result of funding it received. In March 2007, the American Competitiveness Initiative Funding it received enabled allocation of more resources to WMD's efforts to support the U.S. transition to a hydrogen economy. In August 2007, the U.S. DOE and NIST WMD entered into an Interagency Agreement for a five-year project for the Development and Implementation of Commercial Hydrogen Measurement Standards and Test Procedures.

NIST WMD’s Long Range Plan is to promote the building and to support the legal metrology infrastructure from its initial implementation phase through any necessary evolution of the plan to accommodate changing technology and emerging marketplace practices for commercial hydrogen measurements along the following timeline:

2008
Analysis and work plan
Draft device standards*
Compare draft standard* to corresponding international standards

2009
Conduct field trials of draft standard*
Draft test procedures* for devices
Draft method of sale regulations
Draft quality regulations
Develop proposals to introduce or modify corresponding international standards

2010
Conduct field trials of draft test procedures*
Conduct training for test and inspection of devices*
Develop draft sampling and laboratory procedures*

2011
Finalize device standard and test procedures*
Finalize method of sale and quality regulation*
Finalize sampling and laboratory testing*
Conduct training seminars on implementing standards and testing*
Draft type evaluation criteria*
Draft standard for devices delivering gaseous blends

2012
Conduct training seminars on implementing standards and procedures*
Review and revision of device and quality standards*
Finalize type evaluation criteria and dispenser training*
Conduct field trials for draft standard for gaseous blend devices
Draft test procedures for gaseous blend devices
Draft sampling and laboratory test procedures for gaseous blend devices
Draft test procedures for devices delivering liquid hydrogen
* gaseous hydrogen

(5) What are the Goals of the Work Group?

The USNWG will work to establish a comprehensive set of device, fuel quality, and other legal metrology standards for equipment used in commercial hydrogen measurements for vehicle and other refueling applications. The ultimate goal is that these standards will ensure the accuracy of measurements, enhance consumer protection, foster fair competition, and facilitate economic growth and trade. These USNWG discussed these goals.

Historically it has been demonstrated time and again that weights and measures standards are a necessary part of the legal metrology infrastructure to promote accurate measurements at all levels of commerce. We see examples of how this work in familiar applications such as the service station gas pump and grocery store scales that operate in every neighborhood. Commercial equipment must meet NIST Handbook 44 requirements and the method of sale and practices for advertising a commodity as well as fuel specifications that are outlined in NIST Handbook 130. Many of the existing legal metrology standards for refueling equipment in NIST Handbook 44 can serve as a basis for drafting hydrogen standards. However, given the unique properties of

hydrogen, a number of changes and possibly new procedures must be established using the expertise that exist in the weights and measures and hydrogen communities. NIST WMD has had multiple successes with work groups using industry and weights and measures technical experts on emerging and less known technologies.

NIST Handbook 44 equipment codes will be the basis for test procedures documented in an Examination Procedure Outline and more detailed type evaluation criteria. A large gap in the weights and measures infrastructure can exist if the works stops without corresponding requirements in NIST Handbook 130 to define hydrogen and specify fuel quality specifications, classification, identification guidelines, labeling requirements, and safety and sampling procedures. The USNWG will from time to time need to reassess the resources and best approach to achieve these goals.

(6) National and International Standards for Hydrogen Measurement

NIST WMD is uniquely positioned to represent the U.S. position on legal metrology standards as it works toward harmonizing national and international requirements. The NIST WMD goal is to promote harmonization of these standards to the greatest extent possible and to ensure their suitability for the U.S. marketplace.

Through its participation in the development of legal metrology standards NIST works to consider the interest of all stakeholders and to avoid conflicts with related hydrogen standards developed by national and international standards and codes developing organizations. Participants were briefed on the status of two related International Organization of Legal Metrology documents (OIML) (see Attachments K and L). The status of these internationally recommended standards are as follow:

At the upcoming October 2007 42nd meeting of the International Committee of Legal Metrology, the United States will oppose TC8/SC7 “Compressed gaseous fuel measuring systems for vehicles” because the OIML procedural process for revising the document was not followed and for technical concerns about device security requirements proposed in the document.

NIST WMD is Secretariat for R 81”Dynamic Measuring Devices and Systems for Cryogenic Liquids" and has responsibility for initiating work and ensuring that the standard progresses according to practices established by OIML. In September 2007 after soliciting input from U.S. Stakeholders and members of the TC8SC6 committee, NIST WMD recommended that the Bureau of International Legal Metrology revise the 1998 version of R 81to include: (1) new ISO and IEC Standards as recommended in OIML D 11 "General Requirements for Electronic Measuring Instruments" (2004), (2) new developments in hydrogen measurements, (3) revise density equations, and (4) any other remaining relevant standards and national documents.

The USNWG discussed the work by multiple national and international organizations to develop fuel specifications (see Item 2). The weights and measures community must identify an appropriate specification to reference rather than develop a separate standard. The USNWG is aware of the status of the development of these standards and issues surrounding the test and detection of purity levels and contaminants.

NIST WMD will continue to represent the U.S. interest on these documents, brief U.S. stakeholders (including the USNWG) on any changes in the recommendations status, and continue to seek U.S. input as these guidelines go through periodic updates or as the need arises to make technical modifications to requirements.

(7) Development of Standards for Commercial Hydrogen Measurement

The work to develop weights and measures standards for commercial hydrogen measurements is being accomplished within the existing network of experts in the weights and measures and hydrogen communities

The commercial hydrogen measurement standards necessary to support the hydrogen economy encompass: (1) device and related equipment codes, (2) method of sale requirements, (3) labeling requirements, (4) fuel quality standards, (5) sampling procedures, (6) inspection procedures, test equipment standards, and safety practices, (7) training for officials and service companies, and (8) education of stakeholders on hydrogen measurement.

In 2003, the U.S. DOE requested NIST WMD take a lead role in developing legal metrology standard for hydrogen refueling standards. Prior to April 2007 the NIST WMD could only assign part of one Legal Metrology Devices Group staff person to promoting the developing of hydrogen measurement standards. NIST WMD developed and distributed a first draft of a NIST Handbook 44 Hydrogen Gas Meters Code in February and May 2005 to the weights and measures and hydrogen communities. The document was also posted on the web site http://www.fuelcellstandards.com which includes a matrix that summarizes work sponsored by the federal government and other ongoing worldwide activities related to developing and providing guidelines on hydrogen and fuel cell codes and standards.

Funding received in 2007 is allowing expansion of the work beyond the 2005 1st Draft of the NIST Handbook 44 Hydrogen Gas Meters Code. The limited comments received, where appropriate, were incorporated into the 2005 1st draft (see comments in Attachment A) resulting in a 2nd draft (see Attachment D). On October 3, 2007, the USNWG began work on a 2nd Draft of the Hydrogen Gas Meters Code Work during the group's first meeting to develop commercial hydrogen measurement standards. The USNWG will work through more recent comments (see Attachments B and C) on the 2nd draft in the order that they appear in the code (specifications, test notes, tolerances, and user requirements). The USNWG reviewed plans for a NIST Process Measurements Division hydrogen flow facility that simulates service station dispensing applications. The facility permits research to demonstrate the effects of transient flow, pressure, and temperature on the performance of various flow meter types (see Attachment G). The USNWG agreed to distribute the schematics to their colleagues for input on the concept.

Paragraphs modified by the USNWG and the rationale for their actions are as follows:

<table>
<tr><td colspan="3">October 2007 Modifications to Draft 2.0 of the NIST Handbook 44 Hydrogen Gas Meters Code</td></tr>
<tr><td>Changes to Requirement</td><td>Requirement Title</td><td>Reason for Change</td></tr>
<tr><td>Modify paragraph S.1.1.</td><td>Indicating Elements</td><td>Clarified that the continuous display of the measurement results are relative to quantity and total price.</td></tr>
<tr><td colspan="3">S.1.1. Indicating Elements. – A measuring assembly shall include an indicating element that ~~is capable of~~ continuously displays~~ing continuous~~ measurement results relative to quantity and ~~money~~total price. Indications shall be clear, definite, accurate, and easily read under normal conditions of operation of the instrument.</td></tr>
<tr><td colspan="3"></td></tr>
<tr><td>Modify paragraph S.1.2.</td><td>Hydrogen Gas Dispensers</td><td>Since all indications are in mass rather than equivalent volume units, a separate display of mass measured is not required for inspection and test of the dispenser.</td></tr>
<tr><td colspan="3">S.1.2. ~~Hydrogen Gas Dispensers~~ Computing-Type Device. – A hydrogen gas dispenser used to refuel vehicles shall be of the computing type and shall indicate the mass, the unit price, and the total price of each delivery. ~~The dispenser shall display the mass measured for each transaction either continuously on an external or internal display accessible during the inspection and test of the dispenser, or display the quantity in mass units by using controls on the device~~.</td></tr>
</table>

Modify paragraph S.1.3.1.	Units of Measurement	Deliveries shall be indicated in only kilograms (whole, decimal or subdivisions). Air buoyancy is not a factor in the delivery of a gas or liquid delivered into a closed container, therefore there is no need to specify deliveries are in terms of apparent mass versus density. (see Attachments H and J)

S.1.3.1. Units of Measurement. - Deliveries shall be indicated and recorded in ~~grams or~~ kilograms ~~or pounds~~ and decimal subdivisions thereof. ~~The indication of a delivery shall be on the basis of apparent mass versus a density of 8.0 g/cm^3.~~ (REFERENCE THIS SECTION)

Modify paragraph S.1.3.3.	Maximum Value of Quantity-Value Division	Given the low specific gravity of hydrogen, sufficient resolution occurs when the value of the quantity division value is limited to not greater than 1.0 % of the minimum measured quantity.

S.1.3.3. Maximum Value of Quantity-Value Divisions. - The maximum value of the quantity-value division shall be not greater than ~~0~~1.~~2~~0 % of the minimum measured quantity.

Delete paragraph S.3.3.	Maintenance of Vapor State	This requirement is not required since temperatures colder than -400 EF are required for a liquid state.

~~**S.3.3. Maintenance of Vapor State.** – A device shall be so designed and installed that the product being measured will remain in a vapor state during passage through the meter.~~

Add New paragraph S.3.4.(d)	Provision for Sealing	Added security requirements for all metrological parameters that affect the device or system's performance; this modification makes the wording consistent with security requirements that are intended to address any sealable parameters in use on meter technologies where a change or adjustment of that parameter may have a detrimental affect on the metrological integrity of the equipment.

S.3.4. Provision for Sealing. - Adequate provision shall be made for an approved means of security (e.g., data change audit trail) or physically applying security seals in such a manner that no adjustment may be made of:

(a) each individual measurement element;

(b) any adjustable element for controlling delivery rate when such rate tends to affect the accuracy of deliveries; ~~or~~

(c) the zero adjustment mechanism;~~,~~ and

(d) any metrological parameter that will detrimentally affects the metrological integrity of the device or system.

When applicable, the adjusting mechanism shall be readily accessible for purposes of affixing a security seal.

Audit trails shall use the format set forth in Table S.3.4.

Modify paragraph S.3.5.(a) and Delete paragraph S.3.5.(b)	Automatic Density Correction	One requirement addresses the need to automatically correct for all influence factors that affect product density in all hydrogen gas metering systems.

S.3.5. Automatic Density Correction.

~~(a)~~An automatic means to determine and correct for changes in product density shall be incorporated in any hydrogen gas metering system that is affected by changes in the density (e.g., temperature, pressure, or composition) of the product being measured.

~~(b)Mass-measuring devices with automatic temperature compensation used to measure hydrogen gas as a motor vehicle engine fuel shall be equipped with an automatic means to determine and correct for changes in product density due to changes in the temperature, pressure, and composition of the product.~~

Modify paragraph S.3.6	Pressurizing the Discharge Hose	Language was added to clarify that pressurization of the delivery hose must operate so as not to have an affect on delivery that takes the equipment outside of the acceptable limits for accurate registration.

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.

Modify paragraphs S.3.7.(a) and (b)	Zero-Set-Back Interlock, Retail Motor-Fuel Devices	Paragraph requires hydrogen dispensing systems to shut off at the end of delivery and recognizes the operational and design differences in those systems from other motor-fuel dispensing systems (e.g., lack of start lever).

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

(a) ~~after a delivery cycle has been completed by moving the starting lever **or similar mechanism** to any position that shuts off the device~~, when the device is shut-off at the end of a delivery, an automatic interlock 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;

(b) ~~the discharge nozzle cannot be returned to its designed hanging position (that is, any position where the tip of the nozzle is placed in its designed receptacle and the lock can be inserted) until the starting lever **or similar mechanism** is in its designed shut-off position and the zero-set-back interlock has been~~

~~engaged; and~~It shall not be possible to return the discharge nozzle to its start position unless the zero set-back interlock is engaged or becomes engaged.

(c) in a system with more than one dispenser supplied by a single pump, 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.

Delete paragraph N.6.2.	Special Tests	All equipment in use is held to 2.0 % tolerance. Eliminates a reference to special tests since those tolerances were the same as those for equipment in use.

~~**N.6.2. Special Tests.** – Special tests to develop the operating characteristics of a meter and any special elements and accessories attached to or associated with the device, shall be made as circumstances require. Any test except as set forth in N.6.1. shall be considered a special test. Special test of a measuring system shall be made to develop operating characteristics of the measuring systems during a split compartment delivery. (See Table T.2.)~~

Modify Table T.2	Accuracy Classes for Hydrogen Gas Meter Applications	No blended products containing 20 % or less hydrogen will be addressed in this code. Those blends will be considered part of the codes that apply to CNG applications.

Table T.2. Accuracy Classes for Hydrogen Gas Meter Applications

Accuracy Class	Application or Commodity Being Measured	Acceptance Tolerance	Maintenance Tolerance	~~Special Tolerance~~
2.0	~~Compressed natural gas~~**,** ~~**as a motor fuel and**~~ ~~h~~Hydrogen gas~~**, and compressed natural gas and hydrogen blends**~~ **as a motor fuel**~~s~~	1.5 % (STAY OPEN FOR DISCUSSION)	2.0 %	~~2.0 %~~

Add new UR.1.1.	Computing-Type Device	Devices must be computing type indicating mass, unit price, and total price to allow for value comparisons at all service stations and other motor-fuel products.

UR. 1.1. Computing-Type Device. – A hydrogen gas dispenser used to refuel vehicles shall be of the computing type and shall indicate the mass, the unit price, and the total price of each delivery.

UR.3.1.	Unit Price and Product Identity for Retail Dispensers	Unit price and product identity must be displayed since UR.1.1. was modified to require all hydrogen dispensers be of the computing type to make value comparisons in the marketplace.

UR.3.1. Unit Price and Product Identity for Retail Dispensers. - ~~In the case of a computing type or money-operated type, t~~The unit price at which the dispenser is set to compute shall be conspicuously displayed or posted on the face of a retail dispenser used in direct sale.

Renumber and modify paragraph UR.3.5.	Steps After Dispensing	Paragraph requires the compliance of hydrogen dispensing systems after a delivery and recognizes the operational and design differences in those systems from other motor-fuel dispensing systems.

UR.3.~~6~~5. Steps After Dispensing. - After delivery to a customer from a retail motor-fuel device:

~~(a)the starting lever **or similar mechanism** shall be returned to its shutoff position and the zero-set-back interlock engaged; and~~

~~(b)the discharge nozzle shall be returned to its designed hanging position unless the primary indicating elements, and recording elements, if the device is equipped and activated to record, have been returned to a definite zero indication.~~

(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 doing so. (REWORK "BY DOING SO" AND CONSIDER CHANGING "START" TO REST)

Other items discussed by the USNWG that may require further research to determine the effects on accuracy and test procedures are:
(1) location of the meter which may vary and can be located within the dispenser cabinet or at the compressor and
(2) fill protocols to address the differences in 350 bar and 700 bar dispensing systems.

The USNWG will consider the all remaining comments and code paragraphs not addressed during this meeting at the spring 2008 USNWG meeting when the USNWG resumes work on the Draft Hydrogen Gas Meters Code (Attachment E).

(8) Next Steps/Tasks
At the conclusion of the meeting, the USNWG agreed that the level of work necessary to complete the line item review of the 2nd Draft of the Hydrogen Gas Meters Code dictated this item be carried over to the next meeting. Eventually the USNWG will explore working by conference calls and email. The USNWG agreed that simultaneous work should take place to develop equipment standards and test procedures for gaseous hydrogen refueling applications (see Item 2 for more background). A new fuel specifications subcommittee will meet in a separate session at the next in-person meeting to determine strategies for determining the most appropriate fuel specification and corresponding quality sampling and laboratory test methods to reference in NIST Handbook 130. The USNWG agreed that a back-to-back work session for the device standards and fuel specifications groups since stakeholders with interest in both standards areas would be present. This strategy might expedite the work and result in less travel expenses for group members. The USNWG may explore this strategy for other meeting. No projects target dates were identified at the October 2007 meeting.

(9) Next Meeting

Four additional work group meetings are tentatively planned for February, May, and August 2008, and the fifth is to be determined. Arrangements will be made to confirm a date in the February/March time frame for holding the second USNWG meeting at the California Fuel Cell Partnership (CaFCP), West Sacramento, California. Part of the next meeting will be devoted to the first meeting for the new hydrogen fuel specifications subcommittee. The USNWG will be notified of meeting arrangements and requested to submit issues for the next meeting. The USNWG was also notified that NIST plans to hold two 8-16 hour work shops dedicated solely to introducing and bringing weights and measures regulatory officials (field, laboratory, and administrative) up to speed about standards for hydrogen refueling equipment and to encourage their participation in the process. Tentative dates for these workshops are June and September 2008.

Appendix P	
Glossary of Terms and Publications	
EPO	Examination Procedure Outline
H2	Hydrogen
NBS	National Bureau of Standards now the National Institute of Standards and Technology (NIST)
NIST Handbook 44	Specifications and Tolerances and Other Technical Requirements for Weighing and Measuring Devices. Publication available at www.nist.gov/owm
NIST Handbook 130	Uniform Laws and Regulations in the Areas of Legal Metrology and Engine Fuel Quality. Publication available at www.nist.gov/owm
OIML	International Organization of Legal Metrology
QA	Quality Assurance
SOP	Standard Operations Procedure
TC/SC	Technical Committee/Subcommittee
TS	Technology Services

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

October 3-4, 2007

Appendix Q

Attendant List

USNWG Hydrogen Devices and Fuel Specification Subcommittee Members

Name	Agency	Phone	Email	Attended Yes/No
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Attendant List
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Name	Agency	Phone	Email	Attended Yes/No
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Appendix Q

Attendant List
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