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Considerations When Determining the Method of Sale for Liquefied Natural Gas (LNG) and Compressed Natural Gas (CNG)

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SIThis article was developed by National Institute of Standards and Technology (NIST), Office of Weights and Measures (OWM) and originally titled "Measurement and Marketing: Considerations when Determining the Method of Sale (MOS) for Liquefied Natural Gas (LNG)/Compressed Natural Gas (CNG)." This discussion was first published as a companion piece to industry's viewpoint on a proposal to modify NIST Handbook legal metrology requirements for commercial vehicle fueling equipment and the MOS for CNG and LNG. Both perspectives appeared in the article "Weighing In: Two different organizations offer their stance on how to measure CNG and LNG" published in the spring 2015 edition of The Source: The Voice and Choice of Public Gas, Vol. 7, Issue 3, pp. 10 – 13, which is also available at: http://www.nxtbook.com/naylor/PGAQ/PGAQ0115/index.php#/12.

The following information, based on the NIST OWM piece published in *The Source*: (1) addresses an issue currently being considered by the U.S. weights and measures community and natural gas industry; and (2) is being reprinted to provide the legal metrology community with fundamental philosophies that are used along with technical principles for good measurement practices to establish a uniform and traceable MOS for sale of commodities by weight, measure, or count.

The basic principles of measurement used in trade and commerce date back thousands of years and must be understood by everyone, buyers and sellers, businesses and consumers. To put it simply, measurements in commerce must be clear, transparent, verifiable, and understandable to protect consumers and ensure fair competition among businesses. In the United States, our forefathers understood the importance of good measurement in commerce; John Quincy Adams wrote, "Weights and Measures may be ranked among the necessaries of life…and is often learned by those who learn nothing else, not even to read and write." To that end, Congress has passed various legislations associated with ensuring uniform measurements in the marketplace, including the creation of the Office of Weights and Measures in 1836 and the signing of the Treaty of the Meter in 1875. With the founding of the National Conference on Weights and Measures by the National Bureau of Standards in 1905, the United States took a significant step towards assuring uniformity and equity in commerce throughout the states.

Establishing an acceptable method of sale is a critical first step in the development of a fair and competitive marketplace for any commodity. For instance, milk could be sold by volume, or it could be sold by mass. If both were allowed, the measurement principles cited above would be violated. That is, a volume of milk purchased at one location could not easily be compared by a consumer against a weight of milk purchased elsewhere and, thus, frustrate value comparison. For this reason, milk is only allowed to be sold by volume in retail stores. History has shown that when products are introduced into the marketplace without a legally defined standard, confusion and unfair competitive practices can quickly evolve and potentially harm the consumer's perception of the product and business reputation of the seller. For example, at one time, precious metals were being sold by the troy ounce as well as the

avoirdupois ounce. Unscrupulous dealers would buy gold by one unit and sell by another, taking advantage of unaware customers.

When faced with deciding on the best method to advertise and sell a new commodity, existing trade practices are reviewed to determine what already works and what can be improved. This review should include a look at what occurs globally. Another consideration is how the product is measured at the time of sale. Perhaps most importantly, and in keeping with the Treaty of the Meter, measurements made in commerce must be traceable to the International System of Units (SI). The requirement of traceability allows for interstate and international commerce, and provides assurance that a measurement made at one location is comparable to a measurement made across the country or around the world. In looking at the method of sale for gasoline, historically it has been sold by volume. It is sold by volume around the world, and it is measured and dispensed by volume. NIST has the responsibility for fixing standards for measurement. As an example, it can be shown that the unit of volume used in the United States, the gallon, is traceable to the SI: One gallon is defined in NIST Handbook 44, "Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices," as exactly 231 cu in and an inch is defined as exactly 0.0254 m, with the cubic meter being the SI unit of volume. Because the SI, the modern metric system of measurement, is becoming the dominant measurement system used in international commerce, NIST Special Publication (SP) 811, "Guide for the Use of the International System of Units (SI)," and NIST SP 330, "The International System of Units (SI)," are the legal interpretations of and guidelines for the use of SI in the United States. NIST definitions of measurement units can be supported and verified throughout each level in the hierarchy for traceable measurements.

Although it is a more complicated measurement, the same logic can be applied to the sale of natural gas as a vehicle fuel (Compressed Natural Gas [CNG] or Liquefied Natural Gas [LNG]). Globally, with the exception of the United States, the product is sold by mass (kilogram). This is largely because natural gas dispensed as vehicle fuel is, for the most part, measured and dispensed by mass. In the United States, the product is also measured and dispensed by mass, and the measurement is verified in pounds; however, this vehicle fuel is sold in fuel equivalent units (gasoline gallon equivalent [GGE] or diesel gallon equivalent [DGE]).

It has been suggested that the most appropriate method of sale of these fuels would be by their energy content. This would be analogous to a home owner's purchase of natural gas heating fuel metered by a temperature compensated vapor meter. The owner is billed on the metered usage that is converted to its value in therms (a heat value equal to 100 000 Btu [1.05 x 10_2 MJ] at a specified temperature). However, vehicle fueling occurs over a short period of time and the energy content of the fuel depends on the fuel's constituents, source, the season, reservoir of product in storage, etc. How much energy the vehicle can glean from a tank of fuel will depend on the engine's efficiency, vehicle load, terrain, environment, and a host of other factors. So, in 1994 both industry and the weights and measures community agreed that attempting to establish and maintain a precise conversion between the actual energy content of gasoline and natural gas and to maintain and verify the relationship was considered to be an unrealistic task at the retail level.

Over the course of an actual fuel delivery an automatic means should be in place to correct for energy content fluctuation which contributes to the variation in energy equivalent content for a fuel product. Unfortunately, to indicate an averaged or estimated energy equivalent unit on the fuel dispenser's total quantity display breaks the hierarchy of traceability, which is necessary for rigorous and credible measurements. An equivalent unit based on an estimated energy content does not provide the consumer

with the measured quantity of product being dispensed, violating the basic principles of measurement in trade and commerce.

As a result, the natural gas market is faced with competing desires between sound trade practices and the ability to market natural gas in terms to which consumers can relate. One potential solution could be to allow for the sale of natural gas by mass (as it is dispensed and measured) and to recognize its marketing by the fuel gallon equivalent (for comparison shopping). Supplementary information such as this is used to market a variety of products, such as laundry detergent (approximate number of wash loads) or shredded cheese (approximate number of cups); however, this "comparison" information is not used as the basis for sales.

It has been more than two decades since the community's move to recognize a conversion value that resulted in the creation of a supplemental fuel "unit" of measurement. The supplemental unit is in use for CNG fuel advertisement and part of the equation used to calculate the sales transaction. If the community moves in that same direction to create yet another supplemental natural gas vehicle fuel unit, then the community is encouraged to use and document recognized scientific methods for establishing such a conversion factor. The 20-year old MOS practice for CNG continues to convert based on a fixed conversion factor that was derived using the lowest estimated energy content value for a specific type of fuel; while acknowledging that the energy content for a supply of fossil fuel even when it meets a fuel quality standard is in a constant state of fluctuation.

In 1993, studies were conducted using averaged energy data to compare one fossil fuel to another, that is, the mean natural gas composition based on the Wobbe number and the lower heating value for gasoline (i.e., "indolene"), to arrive at a list of possible conversion factors. The factor the community chose would be applied to the mass metered by the CNG dispenser and converted to the gasoline gallon equivalent (GGE) value of CNG for use in the quantity display and then the GGEs would be used to calculate the total dollar value for each sale. This practice may not take into account the effect that variations in thermophysical and other properties of the fuel have in the determination of commercial measurement results. Alternative fuels offer safe clean, domestic sources of energy for the United States. It is anticipated that the community will receive future requests for ways to make comparisons between other or newer alternative fuels. Therefore, it becomes necessary to utilize the most current technology and data to provide supplemental comparison information in a uniform and fair manner. This will to avoid confusion and giving an unfair advantage to any one fuel sector. The community should be able to point to rigorous methodology that can clearly and repeatedly be used to arrive at each conversion factor. The use of a supplemental fuel equivalent unit should be studied to determine the impact of reporting quantities to other agencies to avoid confusion or the creation of trade barriers because of erroneous use of the term or expanding its use into other disciplines where similar principles do not apply.

As noted above, there is one option the community discussed in 2014 that offered some flexibility, where natural gas vehicle fuel sales are conducted on the basis of mass in a traceable unit of measurement but which also recognized use of separate supplemental fuel comparison information or the fuel gallon equivalent (strictly for comparison shopping). In this option, a fixed conversion factor would be recognized and used throughout the United States. To permit other than a fixed factor would require monitoring by the authorities to eliminate instances of exaggerated claims about a variable fuel supply's (seasonal, comingled storage, etc.) energy content. In February 2015, a new work group was formed that includes members from the weights and measures and natural gas communities to review the scientific data and other background materials cited in support of the newly proposed values for the conversion of mass

measurements of natural gas vehicle fuels to approximate diesel gallon equivalent units. The work group at the time of publication of this article had not yet reached a consensus on the data used to arrive at the proposed conversion factors. NIST OWM encourages the use of reliable and approved measurement technology that can be supported (i.e., measurements calibrated and traceable back to SI units) by the legal metrology infrastructure. In July 2015, the U.S. standards development process returned a proposal to recognize a second fuel "equivalent unit" for the second time. The standards development process allows for further consideration of that proposal (or an alternative) by the NCWM Specifications and Tolerances Committee (for device requirements) and the NCWM Laws and Regulations Committee (for MOS requirements). NIST OWM encourages the community to revisit alternative MOS proposals intended as a compromise that would ensure traceability of the units of measurement at the time of fuel delivery while offering supplemental information that allows for fuel comparisons.