December 10, 2014

Testing Compressed Natural Gas Retail Motor-Fuel Dispensers

ARRIVING PREPARED TO TEST

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As the developing infrastructure for fueling vehicles that use compressed natural gas (CNG) as an engine fuel continues to unfold, some weights and measures jurisdictions are raising questions about the equipment needed to test the retail motor-fuel dispensers (RMFDs) that dispense CNG. The testing of CNG RMFDs necessitates some advance planning to ensure that all of the proper test equipment is available on the day that testing is to take place. There is information that officials can gather beforehand that will allow them to make a preliminary determination of whether or not the equipment made available to them for testing will be adequate and improve the likelihood that a complete test, as outlined in NIST EPO No. 28 Examination Procedure Outline for Compressed Natural Gas (CNG) Retail Motor Fuel Dispensers, can be performed on the date that testing is scheduled. This article identifies the information that needs to be known about the test equipment as well as the RMFD to be tested and explains how this information is used to make this determination.

Note: The word "preliminary" prefaces the word "determination" in the above paragraph for good reason. CNG RMFDs are tested gravimetrically, which requires the use of a suitable reference scale that has been proven to be sufficiently accurate and capable of repeating its indications. The reference scale is tested onsite, immediately prior to being used as a transfer standard in testing the CNG RMFDs. Testing of the reference scale typically takes place outdoors, under existing weather conditions, and in close proximity to where the scale will be used to weigh test drafts of CNG. The results from such onsite testing determine whether or not the scale performs well enough to be used as a standard in testing another device; in this case, a CNG RMFD. For this reason, even when a preliminary determination has been made that the reference scale being made available for testing is adequate (i.e., based on elements of its design), it isn't until the results of testing the reference scale onsite are known that a final determination can be made relative to its adequacy.

Dispenser Information

There are two things that officials need to find out about a CNG RMFD that they are planning to test. The first is the minimum measured quantity (MMQ) marked on the device. The second is how mass units are accessed.

MMQ. NIST Handbook 44, Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices, Section 3.37. Mass Flow Meters Code paragraphs S.5. Markings and N.1. Minimum Measured Quantity requires that the MMQ be specified and marked on the device by the manufacturer.

> **S.5. Markings**. – A measuring system shall be legibly and indelibly marked with the following information:
>
> (a) …
>
> minimum measured quantity; and
>
> (b) …
>
> **N.1. Minimum Measured Quantity.** – The minimum measured quantity shall be specified by the manufacturer.

NIST Handbook 44, Section 3.37. Mass Flow Meters Code Paragraphs S.5. Markings and N.1. Minimum Measured Quantity

The MMQ provides the critical piece of information needed to determine whether or not the value of the scale division (d) of the reference scale will be small enough for the scale to be used as a standard in testing the RMFD. To be small enough, the value of "d" must be less than or equal to one-tenth the smallest tolerance to be applied to the RMFD under test. The smallest applied tolerance on a CNG RMFD is the tolerance that gets applied to the smallest test draft; which in this case, is a test draft equal to the MMQ. The variables used to determine the maximum allowable division size for the reference scale are expressed in formula (1).

$$\textit{Reference scale division } (d) \leq \textit{smallest test load x tolerance} \div 10 \qquad (1)$$

Rearranging some of the variables in this equation also makes possible a determination of the smallest test load of CNG to be delivered into the test cylinder during testing. Formula (2) establishes the smallest permissible test load or test draft size.

$$\frac{Reference\ scale\ division\ (d)\ x\ 10}{Tolerance\ of\ device\ under\ test} = \textit{Smallest test load} \qquad (2)$$

Note: *Error weights or an expanded scale resolution feature, providing the scale is equipped with one, may be used to expand the readability of a scale to a value smaller than "d." If readability can be expanded, it is the value to which a scale can be read that should be inserted for the value of the scale division "d" in formulas (1) and (2) shown above. For example, in formula (1), if d = 0.02 lb and the scale can be put into an expanded resolution and read to 0.002 lb, then it is 0.002 lb, rather than 0.02 lb, that is to be less than or equal to one-tenth the smallest applied tolerance.*

In consideration of these two formulas, it is important to be mindful of the relationship between the value of "d" on the reference scale and the minimum test draft size. Increasing the size of the smallest test draft allows for the use of a reference scale with a higher scale division value. Stated differently, as the value of the scale division increases on the reference scale, so must the size of the smallest test draft.

Accessing Mass Units. CNG RMFDs are required to indicate the delivered quantity in either gasoline gallon equivalent (GGE) units or gasoline liter equivalent (GLE) units as specified in Mass Flow Meters code paragraph S.1.3.1.1. Compressed Natural Gas Used as an Engine Fuel. Even though they must indicate in GGE or GLE units, the dispensers are required to display the mass measured for each transaction. The mass value may either be displayed continuously on an external or internal display accessible during the inspection and test of the dispenser, or the mass value may be accessed using controls on the device as specified in paragraph S.1.2. Compressed Natural Gas Dispensers.

> **S.1.3.1.1. Compressed Natural Gas Used as an Engine Fuel**. – When compressed natural gas is dispensed as an engine fuel, the delivered quantity shall be indicated in "gasoline liter equivalent (GLE) units" or "gasoline gallon equivalent (GGE) units" (see definitions).
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> (Added 1994)
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> **S.1.2. Compressed Natural Gas Dispensers.** – Except for fleet sales and other price contract sales, a compressed natural gas dispenser used to refuel vehicles shall be of the computing type and shall indicate the quantity, 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.
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> (Added 1994)

Section 3.37. Mass Flow Meters Code Paragraphs S.1.3.1.1. Compressed Natural Gas Used as an Engine Fuel and S.1.2. Compressed Natural Gas Dispensers

It is wise to determine how mass units are accessed in advance of arriving on site for a test so that if special assistance or some separate piece of equipment is needed to access the mass units, these can be made available at time of test. Some NTEP Certificates of Conformance (CCs) provide an indication of how mass units can be accessed. If not specified on the CC, the device owner should be able to provide this information.

Test Equipment Information

Given the limited number of CNG refueling stations in some areas of the country, combined with the uncertainty of knowing just how many more might be added in the future, some states are finding it difficult to justify the expense of purchasing the test equipment needed to test CNG RMFDs. As an alternative to purchasing the test equipment, some states are currently opting to require, under the provisions of NIST Handbook 44 paragraph G-UR.4.4. Assistance in Testing Operations, that the owner or operator of the dispensers supplies the specialized test equipment.

> **G-UR.4.4. Assistance in Testing Operations.** – If the design, construction, or location of any device is such as to require a testing procedure involving special equipment or accessories or an abnormal amount of labor, such equipment, accessories, and labor shall be supplied by the owner or operator of the device as required by the weights and measures official.

NIST Handbook 44 paragraph G-UR.4.4. Assistance in Testing Operations

Whether provided by the jurisdiction or the device owner, the following test equipment is needed to perform an official test on a CNG RMFD:

- ***Test cylinder*** – the container (or vessel) that receives the test drafts of CNG that are dispensed during the testing of a CNG RMFD.
- ***Reference scale*** – the scale used to determine the actual weight of the CNG delivered into the test cylinder for each test draft.
- ***Test weights*** - physical standards that meet specifications and tolerances in NIST Handbook 105-series handbook (or other suitable and designated standards) that are used to test and determine the adequacy of the reference scale prior to it being used as a transfer standard in the testing of a CNG RMFD. Test weights of smaller value, known as "error weights" are sometimes needed to reduce rounding errors and expand the readability of a digital electronic reference scale so that it can be read to a value less than its displayed scale division.

Test Cylinder

NIST EPO N0. 28 Examination Procedure Outline (EPO) for Compressed Natural Gas (CNG) Retail Motor Fuel Dispensers provides a list of criteria officials need to verify concerning the test cylinder. The EPO indicates that the following should be considered when selecting a test cylinder:

- rating must be equivalent to or greater than the service pressure* marked on the device under test as required by the ANSI/IAS NGV 4.1/CSA 12.5 "NGV Dispensing Systems," Standard for Natural Gas Vehicle Dispensing Systems;
- compatible fittings that allow for the connection of the dispenser discharge nozzle;
- bleed valve;
- pressure gauge;
- drain hose; and

- means for grounding the cylinder prior to connecting to dispensing equipment such as a quick connect ground strap.

***Note:** Service pressure is the settled pressure at a uniform gas temperature of 21 oC (70 oF) and full gas content. It is the pressure for which the equipment has been constructed under normal conditions. This is different from the maximum working pressure.

In addition to verifying that a test cylinder complies with all the criteria listed in the NIST EPO, the capacity of the test cylinder (i.e., the amount of CNG it will contain) is needed to determine whether or not it is of sufficient capacity to be considered suitable for use in testing the particular RMFDs that are planned. In order to be considered suitable, the test cylinder must be able to hold at least three times the value of the minimum measured quantity (MMQ) marked on the dispenser for the following reasons:

- MMQ is an operational rating declared by the manufacturer of the equipment and provides an indication of smallest quantity that can be accurately measured by the device. This rating applies to both use and testing of a device. Thus, it would not be appropriate to dispense an amount less than the MMQ for any tests intended to verify accuracy of the device; nor would it be appropriate for an operator to dispense a quantity less than the MMQ.
- A segment of the overall test to verify accuracy of a CNG RMFD, as outlined in EPO NO. 28, requires the completion of three consecutive test drafts, each equal to one-third test cylinder capacity. The first test draft is dispensed into the empty test cylinder. The second and third test drafts are initiated with product from the previous test draft(s) remaining in the test cylinder. The test cylinder should be full after completion of the third test. Since it would not be appropriate for any test draft to be less than the MMQ, the test cylinder needs to be able to hold at least three times the value of the MMQ to accommodate proper completion of these three consecutive, one-third capacity tests.

Reference Scale

Aside from having to test a reference scale to prove its adequacy prior to using it as a transfer standard, there are four important questions relating to elements of scale design that need to be answered to determine whether or not a reference scale is adequate.

1. Is it intrinsically safe?
2. Is the value of the scale division small enough that rounding errors won't use up too much of the tolerance to be applied to the device under test?
3. Is the capacity large enough to weigh a test cylinder full of product?
4. Does its design accommodate ease of application and proper positioning of the test cylinder during testing?

The following provides a discussion of these questions and explains their significance in determining the adequacy of a reference scale.

- ***Intrinsically safe?*** NIST EPO NO. 28 provides the following guidance on intrinsic safety as it relates to a reference scale: scale meets Underwriters Laboratories (UL) Area Classification Class I Division 2 Group D (scale equipment must be located outside of the classified area, which is five feet from the hose fueling connection to the dispenser). It's important to confirm that the reference scale complies with the UL standard specified due to the high flammability of CNG.

- ***Is the value of "d" small enough?*** As explained earlier in the section of this article titled "The RMFD," the value of "d" is small enough when the scale can be read to a value that is less than or equal to one-tenth the tolerance to be applied to the RMFD. Therefore, to determine if scale resolution is appropriate, one only needs to know the value to which the reference scale can be read; the tolerance to be applied to the RMFD during testing; and the MMQ marked on the dispenser. If the scale is to be setup and used outdoors, it's also a good idea to determine if shielding will be made available to reduce the effect of wind.

- ***Is the scale capacity large enough?*** The scale selected for use must have a capacity large enough to weigh a test cylinder full of product including the weight of any shims, cart, or other accessory items that will likely be applied to the scale when weighing the test cylinder during testing. Therefore, one must have knowledge of the approximate weight of the empty test cylinder selected for use in testing and also the approximate weight of the CNG that it will contain when full. When added together, the result equals the approximate weight of the test tank full of product. In some cases, the supplier of the test cylinder may be able to provide the approximate weight of the cylinder full of product. If not, he or she should be able to provide the approximate weight of the test cylinder empty and the volume capacity of the test cylinder in GGEs or GLEs. The volume capacity of the test cylinder can be converted into weight by multiplying the volume capacity value by its associated conversion factor (5.660 lb for a volume capacity specified in GGEs and 0.678 kg for a volume capacity specified in GLEs) to determine the capacity of the test cylinder in units of weight. The approximate weight of a test tank full of CNG may then be determined by adding the weight of the empty test cylinder to that of the CNG contained in a full test cylinder.

- ***Does its design accommodate ease of loading and proper positioning of the test cylinder?*** Determine the approximate weight of the test cylinder in an empty state and when full of CNG to gain a better understanding of the amount of weight to be moved and hoisted onto the scale. Determine the type of scale selected for use and the ease with which the test cylinder can be safely applied to the load receiving element, both when empty and when full of CNG. Confirm that when the test cylinder is positioned on the scale for weighing, the load is distributed evenly over the main load supports of the scale and does not produce binding or off-center loading. A preliminary determination of whether or not scale design accommodates ease of loading and proper position of the test cylinders can be made based on a comparison of the type of reference scale used, size test cylinder and its weight when full of product.

Test Weights

Based on a NIST OWM recommendation that reference scales used in the testing of CNG RMFDs be tested to at least the weight of the largest test draft of CNG to be weighed, the weight of the test cylinder full of product must be known to determine the minimum amount of test weight that will be needed to test the reference scale. NIST Class F standards are generally of sufficient accuracy to test a reference scale that will be used to weigh test drafts of CNG dispensed from a RMFD.

Summary: When planning for the test of a CNG RMFD, it is always a good idea to obtain the information necessary to determine whether or not the different test equipment made available for testing will be adequate. This article was developed to assist in identifying the information that is needed and explain how that information is used to make this determination. Verifying in advance that the equipment being supplied is suitable improves the likelihood that testing can be safely completed and with confidence at the time scheduled. For additional information regarding this article, please contact Rick Harshman at richard.harshman@nist.gov or by phone: (301) 975-8107.

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