

Annex No. 2

Reference Scale Selection Criteria, Performance Requirements, and Use in Accuracy Verification for Compressed Natural Gas (CNG) Retail Motor-Fuel Dispenser (RMFD) Applications

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Annex No. 2
NIST Examination Procedure Outline (EPO) Annex for
Reference Scale Selection Criteria, Performance Requirements, and Use in Accuracy Verification
for Compressed Natural Gas (CNG) Retail Motor-Fuel Dispenser (RMFD) Applications

1. Scope.

This annex serves as a supplementary procedure to EPO No. 28 Compressed Natural Gas (CNG) - Retail Motor-Fuel Dispensers, outlining key considerations and requirements for selecting and verifying a scale suitable for assessing the accuracy of test loads of product dispensed by a compressed natural gas retail motor-fuel dispenser.

2. Accuracy Requirements.

2.1. Method of Accuracy Verification.

Verifying the accuracy of a compressed natural gas (CNG) retail motor-fuel dispenser (RMFD) necessitates using a scale to weigh the CNG dispensed by the device to determine the actual quantity of product in a delivery. The verification procedure that is followed uses the scale to establish the actual quantity of product delivered in a test draft; that value is then compared to the quantity indicated on the RMFD (device under test) to determine if the dispenser meets applicable accuracy tolerances.

2.2. Verification of the Device Under Test.

The scale used to weigh and verify each test draft amount is often referred to as a “reference” scale. This is because this instrument is used to determine if the mass of each CNG delivery by the dispenser falls within the allowed accuracy tolerance. This is possible because the scale’s performance is compared against calibrated mass standards using statistical methods to demonstrate that its repeatability, uncertainty, and errors in its measurements are within acceptable limits. This ensures that this instrument’s performance is sufficient to ascertain that of the dispenser. More simply stated, when the reference scale is used to weigh product delivered from a commercial weighing or measuring device or system, the scale does not serve as the standard but helps to establish the mass of the product by comparison to calibrated field standard weights. The scale in use is called a reference scale because it is capable of being more accurate than the RMFD, and its design provides an adequate and suitable means that can be used to compare the scale’s indicated mass to the mass shown by the dispenser, thereby ultimately assessing the dispenser’s performance. The process described in this procedure, with some appropriate modification, may be used for selecting and using reference scales to verify commercial measurements of other commodities.

2.3. Accuracy of Test Standards.

The Fundamental Considerations of NIST Handbook 44 Appendix A requires that when establishing and maintaining the accuracy of a standard used to test commercial equipment the standard used without correction and its combined error and uncertainty must be limited to or be less than one-third of the tolerance applied to the device under test. This ensures the device is tested with the maximum benefit of its own applicable tolerance, meaning it reduces the chance of the standard's inaccuracy or uncertainty consuming a significant portion of the device's tolerance.

3. Test Equipment Safe Construction and Proper Loading.

3.1. Safety Considerations.

Acquisition of an appropriate reference scale begins with the selection of a scale design that is “intrinsically safe” with an appropriate Underwriters Laboratory (UL) hazardous area classification

rating for safe operation in the environment surrounding the fuel dispenser, where materials exist at levels that make the area hazardous. If the weighing process is to be conducted outside the immediate area around the dispenser, then an assessment of the level and types of hazardous conditions in that area should be made to determine if monitoring and/or intrinsically safe equipment is necessary.

3.2. Loading Considerations.

The selected scale design must accommodate weighing all test loads, and when applied, those loads should not produce binding or result in off center loading. The reference scale's maximum capacity must be sufficient to weigh the largest anticipated test load (i.e., weight of the test tank plus its contents). The footprint of the test tank, along with all its gauges, handles, stands, and portable handcart permanently attached, and any mass standards used during testing, should not extend beyond the perimeter of the weighing platform.

4. Suitability of the Scale Division Value.

4.1. Relevant Device Features.

The value of the scale division (d) (also called readability) selected for the reference scale must be proportional to the size or quantity of any test-draft loads it will be used to weigh. This relationship is especially important when verifying smaller test loads delivered by the CNG dispenser, such as the minimum measured quantity (MMQ) declared by the dispenser manufacturer.

4.2. Reference Scale Rounding and Display Resolution.

A digital electronic scale rounds indications to the nearest scale division, which can cause a potential error of half the scale division (i.e., $d/2$) for each weight determination. Measures should be implemented to reduce the uncertainty when reading weight values on the reference scale. Selecting a scale with a higher resolution, increasing the resolution to improve readability, or using a larger test draft can help reduce rounding errors. A combination of these approaches might be used to reduce errors. Each scenario must be evaluated on a case-by-case basis to ensure that the right approach or combination of approaches has been selected.

The scale division must be considered in conjunction with the size of the net load because the relationship between these two values significantly affects the instrument's degree of accuracy. This is because the amount of error caused by the digital rounding to the nearest minimum displayed scale division increases proportionately as the load decreases. Using this principle, the scale division should be considered when determining the minimum test draft size, ensuring that the test draft is sufficiently large relative to the inaccuracy resulting from the cumulative digital rounding of weight values by the scale. The inaccuracy introduced by the rounding of indications is less significant when dealing with a large test draft. Therefore, verifying a large test draft yields more reliable results on the performance of the device under test.

The "rounding error" (caused by the scale's reading of the indicated weight value to the nearest scale division) can be kept at an acceptably small level if the value of the scale division does not exceed one-tenth of the tolerance applied to the expected smallest net test load [1]. This also ensures that the cumulative errors, which can occur when reading scale indications, along with other factors that contribute to uncertainty in the reference scale's performance, do not use up the entire tolerance allowed for the test standard. Based on these principles, use Equation (Eq.) (1) shown below to establish the largest acceptable value for the reference scale division (d). The scale selected should be appropriate for use under all applicable tolerances, therefore acceptance tolerances are specified in Equation (1).

Equation 1*Reference Scale Division*

$$\leq 0.1 \times \text{Acceptance Tolerance for the Device Under Test} \\ \times \text{Smallest Test Load}$$

When an expanded resolution is used to increase the readability of the reference scale, the scale's specifications must also comply with Equation (1).

NOTE: Equation (1) establishes the largest acceptable scale division value for a reference scale.

4.2.1. Example of Calculations Used to Determine the Scale Division Value.

Consider a device under test that indicates in inch-pound units with an acceptance tolerance of $\pm 1.5\%$ (Accuracy Class 2.0 mass flow meter) applicable to the device under test. The combined weight of the empty tank and the metered CNG is 50 lb; the tank weight is 48 lb; and the CNG product weight is 2 lb. Determine the maximum scale division for the reference scale.

Using Equation (1) shown above calculate the appropriate scale division value for the reference scale in Example 4.2.1. as follows:

$$\text{Reference Scale Division} \leq 0.1 \times 0.015 \times 2 \text{ lb}$$

$$\text{Scale Division} \leq 0.003 \text{ lb}$$

NOTE: Because NIST Handbook 44 requires scale division values only in increments of 1, 2, or 5 (including multiples and submultiples of these values), the largest acceptable scale division value would be 0.002 lb, unless readability is increased by using an expanded resolution. If readability is increased by using expanded resolution, the value of the displayed scale division could be larger (e.g., 0.02 lb or 0.01 lb) because expanding readability to one-tenth the displayed division, for example, would allow these increments to be read to 0.002 lb or 0.001 lb, respectively.

5. Minimum Net Load to be Weighed on the Reference Scale. [1]**5.1. Key Element of the Reference Scale Design.**

Using similar principles established in the Reference Scale Division Equation (1), it is possible to determine the value of unknown variables in the equation. It is key that the reference scale design is suitable for the verification of the smallest test load. In some instances, it may be found that the range between the smallest and largest test loads to be weighed may be so wide a range that a single scale design is not adequate for use in verification of the dispenser's accuracy across the entire range of deliveries and therefore necessitates use of more than one reference scale.

5.2. Determination of the Minimum Test Draft Load Applied to the Reference Scale.

To determine the size of the smallest acceptable test draft or test load that should be weighed on a reference scale can be determined using Equation (2) shown below. Equation (2) was developed using the Reference Scale Division Equation (i.e., Eq. (1)) where the unknown variable of the minimum test draft size in the equation can be solved as follows:

Equation 2

$$\text{Minimum Test Draft Size} = \frac{\text{Scale Division (Readability of the Scale)} \times 10}{\text{Acceptance Tolerance for the Device}}$$

5.2.1. Calculations for Use in Determining the Minimum Test Draft Size. Consider an example where the reference scale is equipped with a 0.01 lb scale division. Error weights should be used to

increase the readability of the scale to the nearest 0.001 lb. Each weight value is, thus ± 0.0005 lb, reading to the nearest 0.001 lb, but since there are two weighings, one to determine the gross weight and the other to establish the tare weight, the potential for total rounding error doubles to 0.001 lb. If the limit of the error for each weighing is one-tenth of the tolerance, with an acceptance tolerance of $\pm 1.5\%$ (i.e., for an Accuracy Class 2.0 mass flow meter), determine the minimum test draft size.

The Minimum Test Draft Size for this example is calculated as follows:

$$\text{Minimum Test Draft Size} = \frac{0.001 \text{ lb} \times 10}{0.015} = \frac{0.01 \text{ lb}}{0.015} = 0.667 \text{ lb}$$

6. Calibration.

6.1. Metrological Traceability.

The use of a calibrated balance (scale) provides a metrologically traceable result. Usually, the calibration results are documented in a calibration certificate along with an estimation of measurement uncertainty. This provides the basis for two specific assessments: repeatability and accuracy.

6.2. Adjustments and Recalibration.

When selecting the balance, consideration should be given to ensure that it is adjustable so that it provides prescribed indications corresponding to specific values of a quantity to be measured. After an adjustment, the instrument must be recalibrated.

7. Repeatability Evaluation.

7.1. General Performance Considerations.

7.1.1. Repeatability Tests.

The repeatability test assesses the balance's accuracy, meaning the degree of agreement among individual results when the test is performed multiple times.

7.1.2. Testing Prior to Use.

On-site testing of the scale immediately before using it as a reference scale, and positioned precisely where it will be used to weigh the various test loads, needs to address the question:

“Is this scale and the measuring process performing well enough under these conditions to use this weighing instrument to verify the accuracy of the commercial equipment that is about to be tested?”

To perform well enough, the scale and process combined error and uncertainty must be less than one-third the smallest tolerance to be applied to the commercial device under test without any corrections being made to the standard. This is a fundamental consideration required of all field standards used to test commercial devices (NIST HB 44 Appendix A Fundamental Considerations paragraph 3.2. Tolerances for Standards). If this requirement cannot be met, the scale and process should not be used in that location under those conditions. Altering the test site conditions (e.g., adding barriers to reduce wind velocity, moving the weighing process to an area in proximity to the device under test but less impacted by factors such as vibration from traffic) may result in adequate performance of test equipment throughout the entire process.

7.1.3. Correction of Reference Scale Indications.

The absolute accuracy of the reference scale indications used in this process is less critical, as calculations are made to correct any indication errors, which is accomplished by comparing the scale's indications to calibrated mass field standards during the verification process. Of utmost importance is the repeatability of the reference scale and measurement process at that time in the environment where measurements are taking place.

7.1.4. Repeatability of Scale Indications.

7.1.4.1. A scale must be able to repeatedly provide consistent indications to within a very narrow range for the evaluator to have confidence in its reliability for use as a reference to test a commercial device. This includes returning to a zero indication whenever the entire load is removed from the scale's weighing/load-receiving element. Provided a scale can repeat its indications, corrections can be made to offset scale error when using the scale, as long as the amount of error is known at the particular test loads to be weighed.

7.1.4.2. When performing repeatability tests, the reference scale must be read, and that data must be recorded to a resolution suitable for use in testing the intended commercial equipment. That is, the reading of the scale's numerical indications must not result in either dropping or rounding digits to fewer decimal places, and that value must continue to satisfy Equation (1) (i.e., less than or equal to one-tenth the value of the smallest tolerance to be applied to the smallest test load) as described in Section 4.2. Reference Scale Rounding and Display Resolution. Thus, values will be recorded to the full resolution of the reference scale.

7.2. Repeatability Test Procedure.

Repeat the following test sequence (steps 1 through 6) at least 10 times, recording the observed values of O_1 , O_2 , and O_3 for each of the 10 tests. Table 1 below depicts an example of a template that can be used to record the data. This process "simulates" measurements made of the product delivered by the dispenser.

- 1) Start with the scale at no load. Press the zeroing mechanism to obtain and record the no-load (zero) indication.
- 2) Apply an empty test tank and record the resulting scale indication as (O_1).
- 3) Apply test weight(s) equal to the amount of the product needed to fill the test tank and record the resulting scale indication as (O_2).
- 4) Remove the entire load and check if the indication returns to zero. Record any change and press the zeroing mechanism to zero the scale.
- 5) Apply the empty test tank plus the test weights applied in step 3, all at once. Record the resulting scale indication as (O_3).
- 6) Remove the entire load from the scale, record any change in the no-load indication, and repeat steps 1 through 5 for each remaining repeatability test.

Table 1. Worksheet Template for Recording Results of Repeatability Tests

Test	1	2	3	4	5
Zero Indication					
(O_1) Empty Tank					
Test Weight					
(O_2) Indication					
Zero Indication					
(O_3) Simulated Application of a Test Draft Load					
Zero Indication					

7.3. Repeatability Data Analysis.

7.3.1. Test Draft Mass.

Determine the mass of the test draft for each repeatability test as follows:

Equation 3

$$\text{Test Draft Mass} = (O_3 - O_1) \left[\frac{\text{Mass of Test Weight}}{(O_2 - O_1)} \right]$$

where:

- “*Test Draft Mass*” refers to the unknown, i.e., quantity of product delivered by the dispenser for that particular test draft.
- ($O_3 - O_1$) denotes the result obtained by subtracting O_1 (empty test tank weight) from O_3 (combined tank and product weight). It provides an uncorrected value of the net load measured. This value should be approximately equal to the mass of the product dispensed for the test draft.
- “*Mass of Test Weight*” refers to the calibrated test weight (added to the empty test tank in Step 3). It should closely match the expected mass of the product measured for that test draft.
- $\left[\frac{\text{Mass of Test Weight}}{(O_2 - O_1)} \right]$ is the correction factor for the error in the scale at the test load. Here, ($O_2 - O_1$) denotes the observed mass of the test weight. If there is no error in the scale, the numerator and denominator will be equal, and the quotient (the correction factor) will be 1. Otherwise, it will be greater or less than 1.

NOTE: When solving Equation (3), record all calculated test draft mass values to at least one decimal place beyond the scale's indication. For example, if the scale resolution is 0.02 lb, record each test draft mass to at least the nearest 0.001 lb. Do not round calculated values to a resolution less precise than at least one decimal place more than what the scale displays.

7.3.2. Using the Repeatability Test Results to Calculate the Sample Standard Deviation.

Determine the “sample” standard deviation s , as opposed to the “population” standard deviation. Using the results (i.e., the calculated test draft mass) from all repeatability tests, calculate the “sample” standard deviation as follows:

Equation 4

$$s = \sqrt{\frac{\sum |x - \bar{x}|^2}{n - 1}}$$

where:

- x denotes individual test draft mass;

- $\bar{x}$ denotes the mean of the sum of the test draft mass for all repeatability tests, and
- n denotes the number of repeatability tests.

NOTE: *The use of an online standard deviation calculator, as well as the 'stdev.s' and 'stdev' functions of MS Excel, is acceptable for determining the "sample" standard deviation s .*

7.4. Repeatability Requirement.

- Repeatability is evaluated by weighing a single test weight at least 10 times.
- When performing repeatability tests with the scale, position the load in exactly the same way on the load-receiving element each time if using a platform scale, ensuring consistent loading conditions across all tests. Additionally, when weighing test samples of product delivered by the CNG RMFD (assuming the scale is accurate enough for testing the dispenser), each subsequent load should also be placed in the exact same location as the loads used in the reference scale's repeatability tests.

7.4.1. Sample Standard Deviation.

Determine the "sample" standard deviation s , as opposed to the "population" standard deviation. Using the results (i.e., the calculated test draft mass) from all repeatability tests.

NOTE: *Standard deviation measures variability by showing how widely data points spread from their average. A low standard deviation indicates that the data points are closely clustered around the mean, while a high value shows they are dispersed over a much wider range. This measure reflects the average deviation of data points from the mean. The standard deviation of results from multiple repeatability tests helps determine if the scale and measurement process used as the standard, that is used to assess if the dispenser test results show the device reliably repeats its indications, is suitable under current conditions.*

8. Uncertainty Associated with the Measurement Process.

8.1. Establishing the Uncertainty Associated with the Measurement Process. The relationship between the known and the measured values can only be established if the associated measurement uncertainties are derived.

8.2. Use of the Reference Scale Repeatability Tests Results in Determining the Uncertainty of the Measurement Process.

Repeatability testing of the reference scale allows for calculating the uncertainty of the measurement process [2]. The uncertainty value is important for the following reasons:

- It provides a clear indication of whether the combined indication error and uncertainty associated with the measurement process will be less than one-third the tolerance applicable to the device tested, as required in the *Tolerances for Standards* section of the *Fundamental Considerations* in NIST Handbook 44; and
- Its value can be added to the absolute value of the error corresponding to the different test drafts conducted as part of the performance test and used as an indication of whether the device meets applicable NIST HB 44 tolerances. The absolute value of error, plus the uncertainty of the process, must be less than the NIST HB 44 tolerance for the device under test.

8.3. Determining the Uncertainty Value for the Weighing Process.

8.3.1. Use Equation (5) to Determine the Uncertainty Value for the Weighing Process.

Equation 5

$$U = 2 \sqrt{s^2 + \left(\frac{\text{Test Weight Tolerance}}{\sqrt{3}} \right)^2}$$

where:

- U is the expanded uncertainty value;
- s is the calculated “sample” standard deviation (Eq. (4));
- “Test Weight Tolerance” is the specific tolerance that applies to the denomination and accuracy class of the test weights used for the repeatability testing and dispenser test; and,
- $\sqrt{3}$ is a divisor to convert the test weight tolerance to a one standard deviation equivalent by treating the test weight tolerance as having a rectangular probability distribution.

8.4. Requirements When Solving the Uncertainty Equation.

- a. Calculated s value will result in numerical values with multiple digits to the right of the decimal point. Therefore, the s value entered in the equation must extend at least three decimal places beyond the last decimal place of the scale indication.
- b. Do not use rounded values for any of the variables in Equation (5). Carry as many decimal places as possible when solving the equation, and then round the result to two significant figures.
- c. If two or more test weights were used for a repeatability test, the “Test Weight Tolerance” is the sum of the tolerances for all denominations of test weights combined for use in a particular test.

8.5. Allowable Level of Uncertainty.

The expanded uncertainty value, U , must be less than one-third the applicable tolerance for each test draft of product dispensed (i.e., as calculated using Equation (6)):

Equation 6

$$U < \frac{\text{Tolerance}}{3}$$

8.6. Allowable Tolerance for the Combined Error and Uncertainty of Each Test Draft.

For each test draft of product dispensed during testing, the uncertainty value added to the absolute value of the error for the test draft must be less than or equal to the applicable tolerance, (i.e., as calculated using Equation (7)):

Equation 7

$$|\text{Device Error}| + U \leq \text{Applicable Tolerance}$$

NOTE: *It is acceptable to calculate only the uncertainty for the largest test draft and apply that value to all measured test drafts, as long as the requirement from the Fundamental Considerations—that the uncertainty be less than one-third of the applicable tolerance—is met. For any test draft where the uncertainty of the largest test draft does not satisfy the Fundamental Considerations requirement, the actual uncertainty of that specific test draft must be calculated to ensure compliance.*

9. Device Error in the Test Draft Deliveries.

9.1. Adequacy of the Test Standard and Recording Test Results.

Once the reference scale meets the specified design and performance criteria through a process that combines the scale and testing procedures to verify its suitability as a reference, the scale can then be used to determine the mass of various test drafts of the product dispensed during the commercial device

test. The results can be recorded using a test report worksheet template similar to one used for the repeatability test simulation, since the same Test Draft Mass Equation (3) is applied to calculate the actual amount of product delivered by the dispenser for each test draft. Therefore, the results for tests of the CNG RMFD can be recorded in template Table 2. Results of the Dispenser Test(s) as depicted in Section 10.1.

9.2. Steps for the Delivery of the First Test Draft of Product.

Apply the following steps to weigh the first test draft of the product:

- 1) Zero the scale with no load applied.
- 2) Apply the empty test tank and record the scale indication as (O_1).
- 3) With the test tank still positioned on the scale, apply a calibrated test weight equal to the amount of the product targeted for the test draft and record the indication as (O_2).
- 4) Remove the entire load and verify the indication returns to zero. Record the zero indication to monitor drift.
- 5) Dispense product into the test tank to complete the first test draft and record the dispenser indication for later calculation of test draft error.
- 6) Zero the scale indication.
- 7) Weigh the first test draft of the product and record the indication as (O_3).
- 8) Remove the entire load from the scale and verify return to zero. Record the no-load indication.

9.3. Steps for Weighing Subsequent Test Drafts of the Product.

Apply the following steps to weigh the subsequent test drafts of the product:

- 1) Zero the scale with no load applied.
- 2) Apply the empty test tank and record the scale indication as (O_1).
- 3) With the test tank still positioned on the scale, apply a calibrated test weight equal to the amount of the product targeted for the test draft and record the indication as (O_2).
- 4) Remove the entire load and verify the indication returns to zero. Record the zero indication to monitor drift.
- 5) Dispense product into the test tank to complete the test draft and record the dispenser indication for later calculation of the test draft error.
- 6) Zero the scale indication.
- 7) Weigh the test draft of the product and record the indication as (O_3).
- 8) Remove the entire load from the scale and verify return to zero. Record the zero-load indication.

9.4. Calculate the Test Draft's Mass.

Using Equation (3), calculate the mass for each test draft delivery dispensed during testing. Then, record the calculated mass of each test draft on the Dispenser Test Report Worksheet form (i.e., Table 2.) and then calculate the dispenser error for each test draft using Table 3.

9.5. Determine the Amount and Direction of Device Error.

Compare the actual amount of product delivered, as determined from solving the Test Draft Mass Equation, to the amount shown on the dispenser (i.e., as displayed on the dispenser's mass indication accessible during the inspection and test or through controls on the device) for each test draft. The amount and direction of the error are found by subtracting the amount shown on the dispenser from the actual mass measured by the reference scale as calculated using Equation (8) below:

Equation 8

$$\text{Device Error} = \text{Actual Mass} - \text{Indicated Mass}$$

NOTE: The calculation of the device error follows this order so that a negative result indicates the amount a customer would not receive if purchasing the product based on the dispenser indication. For example, if the actual measured quantity dispensed is 4.995 lb but the dispenser indicates 5.000 lb, then the calculated device error is – 0.005 lb. This shows that the customer who paid for 5.000 lb received less product than the dispenser indicated.

9.6. Determine Compliance with the Applicable Accuracy Tolerance.

9.6.1. To determine the applicable tolerance for each test draft, multiply the actual mass (as measured from the reference scale indication) by the percentage tolerance specified in NIST HB 44.

9.6.2. To determine if a test draft meets the applicable tolerance, add the uncertainty value from previous calculations to the absolute error of the test draft. The sum of these two values must be less than or equal to the applicable tolerance, as shown in Eq. (7).

10. Dispenser Test Data and Error Calculation – Worksheets.

10.1. Results of the Dispenser Tests.

Table 2. Results of the Dispenser Test(s)

Test Description	1	2	3	4	5
Zero Indication					
(0 ₁) Empty Tank					
Test Weight					
(0 ₂) Indication					
Zero Indication					
(0 ₃) Test Draft – Scale Indication					
Dispenser Indication					
Zero Indication					
Test Draft Mass					

10.2. Test Draft Mass. Determine the test draft mass from the results of the different dispenser tests recorded above using Equation (3).

10.3. Dispenser Errors. Calculate the dispenser error based on the results of dispenser tests recorded in the table above and the uncertainty value calculated from scale repeatability tests. Record the dispenser errors and compliance in Table 3 shown below:

Table 3. Dispenser Errors

Test Draft Mass	1	2	3	4	5
(minus) Dispenser Indication					
(=) Device Error + or –					
Applicable HB 44 Tolerance					
**Uncertainty Value (<i>U</i>) added to the Absolute Value of the Device Error					
Pass/Fail (P or F)					

** *Uncertainty Value U from Scale Tests – Worksheet:* _____ .

References.

[1] The scale selection criteria and minimum test draft size for mass flow meter technology are discussed in NBS Special Publication 734 in the 1987 Report of the NCWM Committee on Specifications and Tolerances, Item 330-2 Recognize Mass Units for Metering available by request on the NIST OWM website at: <https://www.nist.gov/pml/owm/owm-products-and-services/publications-and-documentary-standards/ncwm-annual-reports>.

[2] NIST Interagency/Internal Report (NIST IR) 6919 Recommended Guide for Determining and Reporting Uncertainties for Balances and Scales available on the NIST OWM website at: www.nist.gov/pml/owm/nist-interagency-or-internal-reports-nistir, includes a comprehensive description of how to determine and address uncertainties in balances and scales.