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Comments on S&T Items 332-5 and 337-3

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Items 332-5 and 337-3 propose changes to the LPG and Anhydrous Ammonia Liquid Measuring Devices Code and the Mass Flow Meter Code to recognize the use of alternate standards to be used to test LPG meters and anhydrous ammonia liquid meters covered by these codes. Comments from the manufacturers supporting these items have stated that the proposals are to recognize alternate field standards for use in these applications. Consequently, the term "transfer standard" is incorrect for this proposal. Field standards have to meet the one-third requirement of the Fundamental Considerations section 3.2.; however, transfer standards that are recognized in some codes in Handbook 44 do not meet the one-third requirement, so that larger tolerances are included in the codes for transfer standards so that the measurement device under test is not penalized for the larger errors and uncertainties associated with transfer standards. The proper agency to evaluate proposed field standards is NIST. If a proposed standard is determined to perform within the required accuracy and uncertainty limits for the proposed measurement application, then a NIST handbook in the 105 series for field standards must be developed and published. Appropriate laboratory capabilities, test procedures and measurement control programs must be established for the calibration processes. To adequately calibrate the proposed alternate field standard, the laboratory calibration procedure must sufficiently cover the range of operational parameters that effect the accuracy and repeatability of the proposed field standard under the field conditions in which the proposed field standard is used in the field.

Each type of proposed field standard must be evaluated based upon the design and performance characteristics of the proposed field standard. Furthermore, the performance of the proposed standard must be evaluated for the characteristics of the fluids (liquids or gases, viscosity and density) that used in the process to test meters. The performance of the proposed standard must be evaluated over the range of parameters of the fluids that are measured in commercial applications, which includes ambient temperatures, product temperatures (particularly at temperature extremes for the commercial measurements), temperature differences between the fluids and ambient temperatures, the range of flow rates at which the fluids are measured, the ranges of pressures (and variations in start and stop pressures) at which the fluids are measured, any potential effects of time and wear on the proposed standard between calibration intervals, and any other variables that could affect the accuracy and repeatability of the proposed field standard. The manufacturer of the proposed alternate standard must explain how the effect of variables that affect accuracy in commercial measurement devices are reduced in the proposed field standard to improve the accuracy and repeatability to meet the one-third requirement for the field standard. For example, if a PD meter is to be used as a field standard to test a PD meter in the field, how has the performance of the PD meter been improved so that it can be used as a field standard?

The proposed changes to Handbook 44 are to increase the time of the minimum delivery for field tests. The companies must identify the variables that require the larger test drafts, and provide explanations and data to justify why these proposed changes are needed for their proposed field standards. Specifically, the data must show that the errors and uncertainties that require the larger test drafts are **constant values** associated with the measurement processes and are not errors and uncertainties that are **fixed percentages** associated with the quantities of fluid delivered. This information must be presented to the S&T Committee before a decision can be made regarding the proposed increases in the sizes of the test drafts for different measurement applications.

Additional Information

The purpose of testing commercial weighing and measuring devices is to determine if they are accurate. Weighing and measuring devices are required to be accurate under all conditions of use. Furthermore, weighing and measuring devices are required to be installed and used as designed and as intended by the manufacturer.

Field standards must be sufficiently accurate over the range of products and over the range of environmental conditions in which the standards are used. The standards are expected to remain accurate throughout the time intervals between the calibrations of the standards. The standards should be easy to use so that different people using the standards should get similar test results. Ideally, the fewer variables that can affect the performance of the proposed standard, the easier it is to calibrate the standard and to assure that the proposed standard is accurate under all conditions of use over an extended period of time. Obviously, test results from different standards should agree within a "small" portion of the tolerance applied to the meters. A thorough understanding of the physics of the measurement processes for the meter and that of the proposed standard is needed to assess the suitability of a proposed standard for its proposed application.

Weighing and measuring devices are tested to determine if they are accurate when used in transactions. This means that the devices must be tested as used. The tests described in the test notes of the many codes in Handbook 44 and the minimum test procedures detailed in the Examination Procedure Outlines are to determine the accuracy of the devices in ways that simulate normal use and as designed by the manufacturer. Furthermore, the proposed standard must be able to test the weighing and measuring devices under the full range of the conditions of use. Any change in these principles require changes to Handbook 44 and the proposed field standards must be covered by a handbook in the NIST 105 series for field standards. Specifically, this paper addresses volume standards to be used to test meters.

Any proposed standard that can satisfy the "one-third" requirement[1] stated in the Fundamental Considerations of Handbook 44 may be used as a field standard. This requirement must be satisfied for the range of products, flow rates, temperatures, pressures, temperature differences that exist which tests are performed, performance over the time between calibrations, and other significant field conditions that may could affect the test results. Corrections to the standards may be used to achieve the desired accuracy over the range of field conditions in which it is to be

[1] NIST Handbook 44, Appendix A, Fundamental Considerations, "**3.2. Tolerances for Standards. –** Except for work of relatively high precision, it is recommended that the accuracy of standards used in testing commercial weighing and measuring equipment be established and maintained so that the use of corrections is not necessary. When the standard is used without correction, its combined error and uncertainty must be less than one-third of the applicable device tolerance."

used. Specific test procedures may be specified to address and reduce some the environmental variables that could affect the test results.

The Evaluation of Proposed Field Standards

For each proposed field standard, issues associated with the design and operation of the proposed standard must be evaluated with respect to accuracy, repeatability and stability over time.

- The design of the proposed standard must be examined to assess factors that could affect accuracy and repeatability over the range of environmental variables in which the proposed standard is to be used. Which variables can affect the accuracy and repeatability of the standard over time?

- The effects of the characteristics of the products to be measured must be assessed for any impact on the accuracy and repeatability of the proposed standard. Which characteristics of the product could affect the performance of the standard?

- Are there any differences in the procedure to test a meter using the proposed standard that are different from the way that the meter system is used in normal operation?

- Does the calibration process for the standard reflect the performance of the standard when used in the field? The calibration process should reflect the accuracy of the proposed standard over the range of field parameters for the products used in the tests of meters.

After the potential variables that could affect the performance of a proposed standard have been identified, it is necessary to determine which test methods are best to evaluate the effects of each variable on the performance of the proposed standard. In some cases, it may be best to conduct tests that isolate a particular variable from any others that could affect performance. Sometimes, side-by-side tests can be helpful to identify general performance problems in a proposed standard, but the side-by-side tests may not allow one to identify the particular problems that are responsible for any discrepancies in the test results.

Examples to Illustrate the Evaluation Process

The use of mass flow meters as master meters has been suggested to test meters in compressed natural gas dispensers and meters used for liquid fertilizers. Examples of issues that should be considered are provided to illustrate the evaluation process, but these examples are not a complete list of the variables and issues that should be considered for each proposed standard. Guidance from experts in each measurement technology is needed to identify all of the significant variables that might affect the performance of an alternate standard in a given application.

Positive Displacement (PD) Meters

Design and Operational Characteristics:

1. PD meters have moving parts. PD meters used as reference standards will be affected by the same variables that affect PD meters that are used in commercial transactions.
2. PD meters used as reference standards are usually calibrated at multiple points over the flow range to correct for nonlinearity in the performance of the meter.
3. PD meters can be used to measure test drafts of different sizes.
4. PD meters may also have corrections for the effects of temperature.

Application: To test meters in retail motor fuel dispensers

Design Characteristic	Variable	(Possible) Effect of the Variable
Accuracy of the PD meter	Temperature	The accuracy of PD meters may change with temperature. The meters may require temperature correction factors that should be verified during calibration.
Accuracy of the PD meter	Flow rates	The accuracy of PD meters varies with the flow rate. Linearity correction factors may be needed. PD meters should be calibrated over the range of flow rates for which it will be used. State W&M labs usually do not have the capability to run calibrations over a wide range of flow rates.
Accuracy of the PD meter	Products (viscosities)	The accuracy of PD meters often varies with the viscosity of the product being measured. The meters must be calibrated for the products that will be used in the tests. This may also apply to corrections for the flow rate and temperature corrections. State W&M labs usually to run calibrations with water.
Accuracy of the PD meter	Time and wear	Reference standards are expected to maintain their accuracy over time, temperatures and products tested throughout the time between calibrations. The stability over time of the calibrations of the PD meter must be demonstrated.
Repeatability	Flow rates, time and wear	The repeatability of the PD meter must be small relative to the repeatability tolerance for the meters under test. The repeatability of the PD meters must be determined over the range of temperatures, flow rates, pressures and products for which it is used to test meters.

Design Characteristic	Variable	(Possible) Effect of the Variable
Fuel compressibility	Pressure	The PD meters measure the volume of the fuel under pressure, but the accuracy of the meter is determined based upon the fuel being at atmospheric pressure. Pressure corrections are needed if this variable is significant.

Mass Flow Meters (MFM)

Experts on mass flow meters should review the validity of the following issues.

Design and Operational Characteristics:

1. MFMs have vibrating tubes, but the tubes are open with no internal moving parts. MFMs meters used as reference standards will be affected by the same variables that affect MFMs that are used in commercial transactions.
2. MFMs used as reference standards are usually calibrated at multiple points over the flow range to correct for nonlinearity in the performance of the meter and to reduce uncertainties.
3. MFMs can be used to measure test drafts of different sizes.
4. MFMs may also have corrections for the effects of temperature.
5. MFMs can measure liquids to a greater degree of accuracy (because of the higher densities) than for gases that have low densities.
6. MFMs usually have corrections for the stiffness of the tubes, which may change with temperature.

Applications: To test meters in compressed natural gas dispensers
To test liquid fertilizer meters

Design Characteristic	Variable	(Possible) Effect of the Variable
Accuracy of the MFMs	Temperature	The accuracy of MFMs may change with temperature. The meters may require temperature correction factors. How are they verified?
Accuracy of the MFMs	Flow rates	The accuracy of MFMs may vary with the flow rate. This may be more significant for gases than for liquids. Linearity correction factors may be needed. MFMs should be calibrated over the range of flow rates for which it will be used.

Design Characteristic	Variable	(Possible) Effect of the Variable
Accuracy of the MFMs	Product densities	The zero reference of MFMs is determined when the tubes are filled with the product being measured, but when there is no flow. Changes in the zero reference affect the accuracy of the measurements. The zero reference may change slightly when different products are measured. It must be determined if the change is zero is significant relative (when products are changed) to the accuracy that is required.
Accuracy of the MFMs	Measuring gases of low densities	Measuring gases of low density is more difficult for MFMs, because the mass of the gas in the tubes is “small” relative to the mass of the tubes themselves. This may limit the accuracy of the measurement process. One manufacturer said that an average density is used for gases. As the pressures vary, the density of the compressed natural gas will vary during the measurement process, which may limit the accuracy of the mass flow meters for this application depending upon the starting and ending pressures in the receiving tanks. This issue applies to both the commercial MFM that is under test and the MFM used as a reference standard. The errors and uncertainties of the reference standard should not exceed one-third of the tolerance applied to the device under test.
Accuracy of the MFMs Tube stiffness	Measuring gases at different pressures	MFMs make corrections for the stiffness of the tube as it changes with temperature. How do the varying high pressures of the compressed natural gas affect the sensitivity of the MFM to measure the mass of the gas flowing through the tubes? This issue applies to both the commercial MFM that is under test and the MFM used as a reference standard.
Repeatability	Flow rates, time and wear	The repeatability of the MFM must be small relative to the repeatability tolerance for the meters under test. How is the repeatability of the MFM used as a reference standard improved over the repeatability of the MFM used as a commercial measuring device?