May 1, 2011

Grain Moisture Meter Test Methods and Tolerances

Byline: G. Diane Lee

Commercial grain moisture meters are responsible for making measurements that affect large volumes of product per device and have a large economic impact. Many of the commercial grain moisture meters in service today are meters that must meet the requirements of NIST Handbook (HB) 44, Section 5.56(a) Grain Moisture Meters. This code applies to all grain moisture meters manufactured or placed into commercial service after January 1, 1998. This code identifies two test methods, the Air Oven Reference Method and the Meter to Like-Type Meter Method; separate tolerances are applied to each method. This article has been written to describe how to use the two test methods and apply the associated tolerances specified in NIST HB 44 Section 5.56(a) in field testing grain moisture meters.

Background

To better understand the system for field testing grain moisture meters, it is necessary to provide some background on the development of calibrations for grain moisture meters. The National Type Evaluation Program (NTEP) for grain moisture meters differs from the type evaluation program for other commercial devices in that there are two phases to the program. In addition to a device evaluation, Phase I, in which a limited number of grains are tested to evaluate the design and calibration of the device, grain moisture meters are also subjected to an annual calibration testing program; referred to as Phase II. The Phase II program verifies the calibration performance with a large number of samples, including difficult to store, high moisture samples, which would be hard to use in Phase I tests. The Phase II program also facilitates meter calibration and standardization to a national, common sample set and a single air oven laboratory. In the NTEP Phase II program, raw data needed for calibration updates to grain moisture meters is collected. The collection of this data is necessary for grain moisture meters because although the device's standard features may remain unchanged each year, individual grain calibrations may change to reflect long-term changes in grain characteristics.

Moisture meters predict moisture content based on an optical (near infrared meter) or dielectric (dielectric meter) measurement of a meter to a grain sample. The current technology for grain moisture meters is grain type/class (e.g., wheat is a grain type, durum such as durum wheat is a class of wheat) specific. As such, a calibration is developed for each grain type/class based on the characteristics of that grain type/class. Because the current technology is grain type/class specific, the relationship between moisture and a grain moisture meter's optical or dielectric response to the biological characteristics of the grain sample (variety, size, weight, etc.) may change with each crop season, thereby necessitating a change to the meter's calibration for that grain type/class. In addition, there is variation in the calibrations for each type of grain moisture meter due to the manufacturer's prediction equations which are used to develop the calibrations for their meter and due to the specific sensing technologies used in different meter types. Simply put, calibrations must be reviewed and adjusted to account for differences in grain crops from year to year.

To determine whether or not a calibration change is needed, as noted above, raw data is collected in the Phase II program on the NTEP laboratory meters using the national grain sample set. The national grain sample set consists of hundreds of current crop year grain samples that are representative of grains from across the United States for the grain types/classes in the NTEP program. The raw data from the NTEP laboratory meters is provided to the manufacturers and the manufacturers use this data to make calibration updates to the grain moisture meters as needed. An NTEP Certificate of Conformance is available to state weights and measures officials, which includes the updated calibrations needed for field inspection of devices. The manufacturers provide the updated calibrations to the device owners to ensure that all commercial meters have the latest calibrations installed in the meters.

AIR OVEN REFERENCE METHOD - FIELD TESTS

When using the Air Oven Reference Method, a grain sample with a reference moisture value is used to test field meters. The reference moisture value of the grain sample is determined using a GIPSA Air Oven test procedure. The field test is performed by measuring the moisture of reference grain samples in the field meter. The field meter moisture measurement is compared to the reference moisture values of the grains. This method is a "mini" test or verification of the meter's calibration; it determines how well the meter's calibration responds to the two to three grain samples (typically of high and low moisture content for each grain type) that are used for testing. Due to the current technology for developing meter calibrations, there is a probability that the samples selected may not perform well on all NTEP meter types. Why would this happen? As discussed in the background section of this article, the current technology for grain moisture meters relies on grain type/class specific calibrations that will vary per meter type. There are a number of samples represented in the national grain sample set, but due to the secondary measurement methods (measuring an optical or dielectric response of a grain sample to predict moisture) and the differences in measurement technologies (prediction equations and sensing technologies), individual samples are predicted with differing levels of agreement to the reference method. Also there is the possibility that if a grain sample that is chosen to test the meter is not represented (due to its variety or other biological characteristic) in the national sample set used to develop the calibration for some measurement technologies, the grain sample may not perform well on the meter. To prevent this occurrence, it is necessary to screen the sample by running the samples through laboratory meters that are maintained in good operating condition, have the latest calibrations installed, and are of the same type as the jurisdiction's field meters that will be tested. If the grain sample moisture tested on the laboratory meter types are within 0.5 % of the reference moisture, the sample can be used to test field meters. Careful sample selection is needed for this test method to avoid failing meters that are operating correctly.

AIR OVEN REFERENCE METHOD – TOLERANCES FOR FIELD TEST

The tolerances that apply to the Air Oven Reference Method are found in NIST HB 44 Section 5.56.(a) Paragraph T.2.1, Table T.2.1. The tolerances are the same for both acceptance and maintenance tolerance. See tolerances below:

Table T.2.1. Acceptance and Maintenance Tolerances Air Oven Reference Method		
Type of Grain, Class, or Seed	**Tolerance**	**Minimum Tolerance**
Corn, oats, rice, sorghum, sunflower	0.05 of the perdent moisture content	0.8 % in moisture content
All other cereal grains and oil seeds	0.04 of the percent moisture content	0.7 % in moisture content

(Amended 2001)

The minimum tolerance referenced in the table is the minimum tolerance to be applied to a test; if the calculated tolerance falls below the minimum tolerance level, the minimum tolerance is applied. To calculate the tolerance, the percent reference moisture of the grain sample that is used for testing is multiplied by the tolerance in Table T.2.1.

Example 1:
Corn Sample with a reference moisture of 14.5 %
14.5 % x 0.05 = 0.72 %
Since 0.72 % is less than the minimum tolerance of 0.8 %, the applicable tolerance for the test is 0.8 %.

Example 2:
Corn Sample with a reference moisture of 16.0 %
16.0 % x 0.05 = 0.8 %
Since 0.8 % is equal to the minimum tolerance of 0.8 %, the applicable tolerance for the test is 0.8 %.

Example 3:
Corn Sample with a reference moisture of 18.0 %
18.0 % x 0.05 = 0.9 %
Since 0.9 % is greater than the minimum tolerance of 0.8 %, the applicable tolerance for the test is 0.9 %.

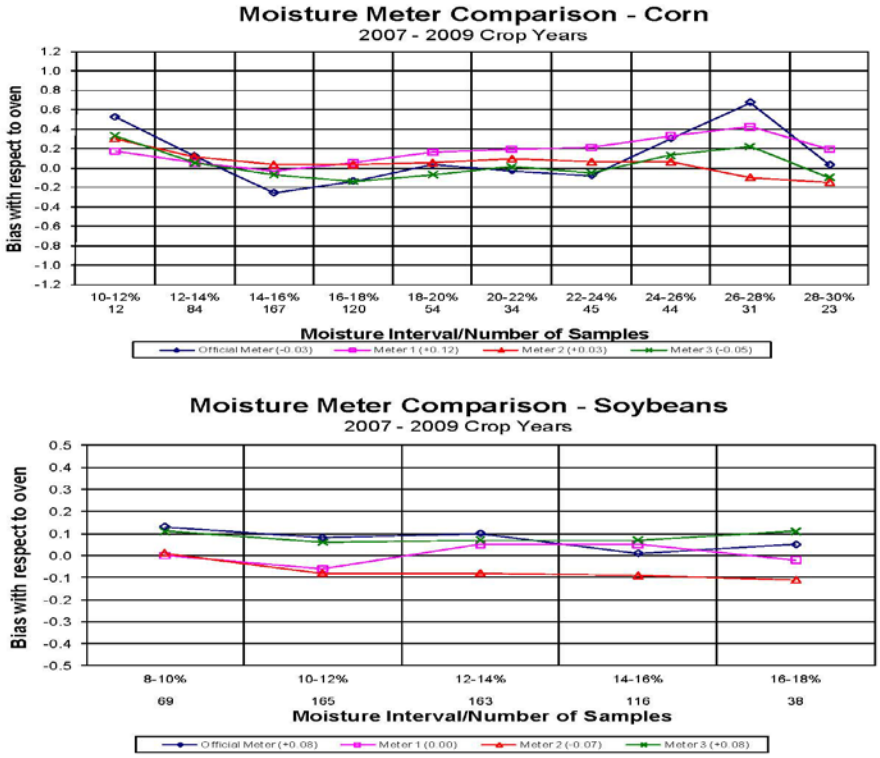
METER TO LIKE-TYPE METER REFERENCE METHOD - FIELD TEST

When using the "meter to like-type meter" test method, a grain sample is used as a comparison medium for a side by side comparison test of a "reference meter" to a field meter of like-type. A reference meter is a meter that is maintained by the laboratory in good working condition, has the latest calibrations installed, and is of the same meter type as the jurisdiction's field meters. The reference meters are used in side-by-side comparisons in the field to test commercial meters of like type. The grain sample is measured in the reference meter and then measured in the field meter under test, and the results are compared. The tolerance in NIST HB 44, Section 5.56(a), Table T.2.1. (see below) is applied to the difference between the two results. It is important to note that the meter to like-type

meter reference method can only be used with NTEP meters because the Phase II calibration testing performed on NTEP meters is a check of the calibration accuracy. This test method verifies that the field meter is functioning similarly to the reference meter and determines if a meter is malfunctioning. It is important that the side-by-side comparison of meters be conducted with a like-type meter, because although the meter calibrations are based on the same sample set, the prediction equations used to develop the calibrations vary per meter type; the sensing technologies may also vary, which causes various meter types to measure differently. If a meter of one type is used to test a meter of another type, errors will be introduced in the test results because of these differences.

Reviews and reports of the variation between meter types in the NTEP Phase II program are annually reviewed at the Grain Analyzer Sector meetings and are included in the reports of the Sector. It should be noted that these variations are much less than in past years because of the NTEP Phase II program. The data below include the grain moisture meter Phase II comparisons for Corn, 2007 - 2009 crops years, which were reported in August 2010. These data illustrate the value of using like-type meters when using a meter to meter comparison method. In the first graph, the official meter has a bias with respect to the air oven of approximately 0.5 % in the 10 % to 12 % range, while another meter type in the same range has a bias of approximately 0.19 %. The official meter has a bias to air oven of 0.31 % higher than this NTEP meter type. If a meter of like-type is not used in the meter to like-type meter test method, any error created by a difference in meter types will be added to the test results.

2007 – 2009 GMM Phase II Comparisons: August 2010



1

METER TO LIKE-TYPE METER REFERENCE METHOD – TOLERANCES FOR FIELD TESTS

The tolerances that apply to the meter to like-type meter test method are found in NIST HB 44 Section 5.56(a) Paragraph T.2.2. The tolerances are the same for both acceptance and maintenance tolerance as shown.

Table T.2.2.
Acceptance and Maintenance Tolerances Meter to Like-Type Meter Method

Sample Reference Moisture	Tolerance
Up to 22 %	0.5 % in moisture content

(Added 2001)

Unlike the air oven reference method for field testing, no calculation is needed to apply the tolerance for meter to like-type meter. The meter to like-type meter tolerance is expressed as a percent value within the table and is applied directly to the difference in the measurement results of the reference meter of like-type to the measurement results of the field meter.

Example 1

A corn sample reads 16.0 % on the reference meter of like -type and the same sample reads 14.5 % on a field meter under test.

14.5 % − 16.0 % = − 1.5 %

Since the difference is greater than ± 0.5 %, the field meter under test does not meet the tolerance specified in Table T.2.2.

Example 2

A corn sample reads 18.0 % on the reference meter of like-type and the same sample reads 18.5 % on a field meter under test.

18.5 % − 18.0 % = 0.5 %

Since the difference is equal to ±0.5 %, the field meter under test meets the tolerance specified in Table T.2.2.

Example 3

A corn sample reads 14.5% on a reference meter of like-type and the same sample reads 14.7 % on the field meter under test.

14.7 % – 14.5% = 0.2%

Since the difference is less than ± 0.5 %, the field meter under test meets the tolerance specified in Table T.2.2.

It is very important that correct test procedures and tolerances be applied during testing. Grain moisture meters, although few compared to other commercial devices, affect high dollar values of product per device.

FUTURE DIRECTION FOR GRAIN MOISTURE METERS

In spite of the limitations of the current technology, there has been progress. Prior to the NTEP program there was a lack of calibration uniformity due in part to the use of different grain sample sets. Calibrations for different meter types were developed with grain samples from different areas of the United States. Also many of the meters were designed such that the user was required to make judgments concerning certain user-controlled factors that would affect the accuracy of the moisture measurement. When the NTEP program was developed, the same meter technology was in use, but the design criteria for the devices changed to remove many of these user-controlled judgments, including sample weighing and moisture look-up charts. NTEP meters directly indicate the moisture on the device and also do not require the user to measure the weight of the grain sample prior to measuring the moisture content of the grain. In addition, instead of calibrations being developed based on varying grain sample sets, calibrations for all meter types are based on the same grain sample set, made up of grains from across the United States. As the calibrations for NTEP meters become more robust, that is more and more grain varieties are included in the grain sample set, over time there may be reduced

issues with sample outliers (grain samples that do not perform well on a meter) in field evaluations of NTEP meters.

Currently, grain moisture meters are being developed that use the same dielectric technology but measurements are made at a higher radio frequency and a uniform equation has been developed. It is anticipated that these new grain moisture meters will not require separate calibrations for each grain type; will be more stable over time; and with the uniform calibration equation, will allow the use of the same calibration equation for all grain moisture meter types. Look for more details on these new grain moisture meters in a future article.

A special thank you goes to Mr. Jack Barber, JB Associates; Ms. Cathy Brenner, USDA, GIPSA; Dr. Richard Pierce, USDA, GIPSA; and Mrs. Tina Butcher, NIST, WMD for their reviews and comments to this article.