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Grain Preparation, Maintenance and Storage of Grain Transfer Standards, Equipment and Apparatus, and Field Test Procedures

Grain Moisture Meter (GMM) Series Part 4

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The most widely used test method for the inspection and testing of GMMs in the United States is the use of grain as a transfer standard. Unlike other commercial devices, these transfer standards are biological samples that require preparation and care to maintain. There are various types of equipment and apparatus needed to test GMMs, including storage and transport containers, temperature measuring devices, and refrigeration equipment. This article, which is the fourth in a series of six articles on Grain Moisture Meters, addresses grain preparation prior to field testing; maintenance and storage of grain transfer standards for field-testing; the equipment and apparatus needed to test grain moisture meters and field test procedures.

The reader is encouraged to review previous articles in this series, including Part 1 “Overview of GMM Series Topics,” Part 2 “Economic Impact of Grain Moisture Meters,” and Part 3 “Grain Moisture Meter Measurement Technology”. The reader is also encouraged to review the May 2004 Weights and Measures Newsletter article for an overview of the process for testing GMMs. These articles can be found on the NIST WMD’s web site at www.nist.gov/owm by selecting “Weights and Measures Quarterly Newsletter Articles” which is located under “Publications,” and then selecting “Grain Moisture Meter/NIR.”

Grain Preparation for Field Testing

The transfer standards used to test GMMs are grain samples. Samples of grain, which are typically purchased or sold within the State’s Weights and Measures jurisdiction, are collected from various farms and elevators. “low” and “high” moisture samples of each grain type are collected. The laboratory staff cleans, labels, and stores the grain for laboratory testing. Laboratory testing is performed to determine which grain samples will be appropriate for use as a transfer standard. GIPSA air-oven test procedures are used to determine the official moisture value of the grain sample. After the official moisture of the grain is determined using the air-oven test method, the moisture of the grain sample is also determined on grain moisture meters in the laboratory. These laboratory meters, which include the same make and models as are used in commercial applications, are maintained in good operating condition, serviced as needed, and contain the most current meter calibrations. The laboratory maintains a meter type of each commercial grain moisture meter within the weights and measures jurisdiction. The difference between the air-oven moisture value and meter moisture value of the grain sample is calculated. If this difference exceeds 0.5% for a particular sample, that sample is considered an “outlier” for that specific meter, and that grain sample should not be used as a transfer standard for testing that specific moisture meter. Such samples are considered “outliers” for these meters because they may not provide an accurate moisture reading when used to test these meters. Outliers may exist because a particular variety of and/or growing seasonal change in a grain sample may not be represented in the pool of grain samples that were used to develop the calibration for the moisture meter. Non-NTEP meters may be more readily affected by outliers because the calibrations for these devices may not be based on a pool of samples that represent grains from across the United States. The calibration of NTEP meters are based on a national sample set of grains from the United States. Grain samples in the national sample set are annually collected using samples that are submitted on a voluntary basis from various States. The national sample set also includes grains that are collected by the NTEP laboratory from various locations within the United States. Along with the current-crop-year’s grain moisture data, the national sample set data also includes the previous two years of grain data, for a total of 3 years of grain moisture data. Although less-frequently occurring in NTEP meters than in non-NTEP meters, outliers may still exist. This is because grains in the national sample set, which are used to develop the meter calibrations, may not include every type and variety of grain available across the country. As mentioned in previous articles, it is for this reason that NIST Weights and Measures Division encourages States to participate in the annual collection of grain that will be used in the pool of samples for the national grain sample set.

Maintenance and Storage of Field Grain Transfer Standards

A set of transfer standards may contain three or more 1-quart or 1-pint jars of each grain type that is representative of the grains grown and sold in a weights and measures jurisdiction at a “high” and “low” moisture for each grain type. Some NTEP meters will need samples of about one quart and Non-NTEP meters will need samples of about one pint for testing. Since both NTEP and non-NTEP meters are typically present in a weights and measures jurisdiction, many laboratories will prepare a transfer standard set with one-quart sample jars so that both NTEP and non-NTEP meters can be tested with the same transfer standard set.

One of the transfer standards for each grain type and moisture level will serve as a back-up standard. The back-up standard is not opened or dropped as often as the other grain transfer standards. Since the back-up standard is used less frequently, it will serve as verification for the grain transfer standard in use. If it is suspected that a particular transfer standard may not be accurate or if a device fails the initial test, the back-up standard can be used to verify the test results.

The grain should be stored in glass containers (see picture of transfer standard storage containers below). The use of tinted glass containers can reduce the effects of environmental conditions on the grain sample. Each one-quart or one-pint sample is labeled with the official air-oven moisture percentage and weight per bushel, grain type, sample identification, and space to record the number of times the sample was opened, warmed and dropped. Drops are when the sample is placed in and run through the meter for testing. Because grain transfer standards are biological samples that will change over time, the use of this transfer standard is limited in the number of times it can be used. Some state studies show that the moisture level of grain samples may begin to change after 18 drops for high moisture (over 18 %) corn and soybeans or 24 drops for other grain types and moistures. Therefore, it is recommended that grain transfer standards should not be used for more than the number of drops noted above, unless your jurisdiction has data to show that the number of drops may be increased without affecting the integrity of the sample. Once an inspector begins using a sample to test meters, time may also become a factor in monitoring the integrity of the grain sample.

The grain transfer standards are to be stored in a refrigerator and maintained at 2 °C (35 °F) to 4 °C (40 °F) until needed (see “Equipment and Testing Apparatus” section in this article). Approximately two hours before use (consider travel time in this two-hour period), the grain transfer standards that will be used for testing that day should be removed from the refrigerator and gently shaken several times (for homogeneity) and placed in a transport cooler (see “Equipment and Testing Apparatus” section in this article) WITHOUT ICE. This will allow them to stabilize to ambient temperature without undergoing temperature extremes. The samples should be spread out to allow the air to move freely about them. Upon arrival at the test site, take the cooler containing the grain transfer standards into the room where the moisture meter is located, and remove the grain transfer standards from the transport cooler. Then, place them in racks near the moisture meter to allow them to equilibrate to room temperature (to within -12 °C (10 °F) of the room temperature) before the jar is opened. To verify that the sample has reached the appropriate temperature, the temperature of the grain sample should be taken with the least amount of exposure to the environment. One method is to replace the lid on the sample with a holed rubber stopper or with a holed lid so that a thermometer can be inserted into the sample. Another method is to use a separate container with a holed lid or holed rubber stopper.



1-quart and 1-pint Transfer standard storage containers with label.

Equipment, Apparatus and Documentation



From Top Right – Portable refrigerators; Digital thermometer; Coolers, Documentation and Grain transfer standards; Rack; and Liquid-in-glass thermometers.

Appropriate test equipment, apparatus, and documentation is needed to test grain moisture meters. A general description of the equipment used to test these devices are as follows:

Certified digital thermometer or certified liquid-in-glass thermometer - A certified digital thermometer or certified liquid-in-glass thermometer that meet NIST HB 105-6 requirements is used to monitor the refrigerator and grain sample temperatures.

Cooler – A cooler of adequate size is used in tempering the official grain samples (Note: Grain samples must not be stored on ice).

Portable refrigerator – A portable refrigerator is used for transporting and maintaining the condition of the samples; a connection to an energy source is needed to maintain refrigerant conditions when transporting the samples from location to location (e.g. some portable refrigerators may be attached to the cigarette lighter in a motor vehicle).

Racks – Racks are used to carry standard grain samples from meter to meter during testing.

Jar lid with a hole or rubber stopper with a hole – A Jar lid with a hole or rubber stopper with a hole is needed to measure the temperature of the grain to determine if the grain sample temperature is appropriate before using the sample to test the meter.

Additional containers may be needed to safely carry any hand tools and mercury-in-glass thermometers.

Documentation - The documentation needed during meter testing includes weights and measures jurisdictional policy and inspection procedures, moisture meter operating instructions, current Certificates of Conformance, and a list of moisture meters within the jurisdiction and the locations, type of meter(s), and type(s) of grain purchased by establishments in the jurisdictions.

Field Test Procedures

The following is an overview of the field test procedures for inspecting and testing a grain moisture meter. For additional information please review NIST HB 44 Section 5.56b.

Prior to testing a grain moisture meter, verify that the meter is functioning properly, check to make sure all moving parts are moving smoothly and correctly, ensure that all displays are indicating properly, and ensure that there are no broken parts on the meter. Proceed with inspecting the meter in accordance with NIST HB 44, Sections 5.56(a) for NTEP meters and 5.56(b) for non-NTEP meters prior to and during testing as appropriate. The following are step-by-step procedures for testing a grain moisture meter for accuracy.

1. Follow the meter operating instructions and select the grain type to be tested on the GMM.
2. Fill the grain hopper with the grain transfer standard which represents the grain type that was selected on the GMM, starting with the high moisture sample first.
3. Drop the grain through the meter and record the results. Repeat the test for a total of three moisture readings.
4. Repeat step 3 with the other meters at the location in assembly-line fashion as quickly as possible with the same grain transfer standard.
5. Return the sample to its original clean jar, seal the jar with the lid, mark the jar with the number of drops and return the jar to the cooler.
6. Analyze the test results only after the selected grain type and selected corresponding grain transfer standard at the selected moisture level are tested in all the meters at the device location and the sample has been resealed and returned to the cooler.
7. Average the three moisture readings for each meter and compare each of the results with the official transfer standard moisture and determine the error, then compare the results with the applicable tolerance.
8. If the meter is in tolerance, proceed to the lower moisture transfer standard of that grain and repeat steps 1 through 7.
9. If the meter is not in tolerance repeat steps 1 through 7 with the back-up sample for that meter. If the results from the back-up sample agree with the results from the primary sample, record the results and return the back-up sample to the cooler and continue to use the primary sample as the standard.
10. If the results from the back-up sample are different, return the primary sample to the portable refrigerator for return to the laboratory. Use the back-up sample as the primary from then on.
11. Repeat steps 1 through 10 for each grain and each moisture level.
12. If appropriate, test the test weight per volume (e.g., test weight per bushel) indications with at least the lowest moisture sample. To do this, drop the lowest moisture sample through the meter 3 times and record the results. Note: Evaluation of the test weight per bushel indications can be performed while testing the moisture indications or weights and measures jurisdictions may choose to use a separate low moisture sample to test the test weight accuracy.
13. Compare the meter results with the official weight per volume of the transfer standard then compare the results with the applicable tolerance for meter test weight per bushel.
14. As appropriate, follow the NTEP certificate "Field Inspection Notes" and review the audit trail of the GMM device for compliance with NIST HB 44.
15. Complete the report form and explain the results to the device owner.
16. As you are conducting the tests, mark each sample label with the number of times each sample is dropped and the number of times the sample was warmed and verify that the seals of the jars are tight before returning the samples to storage.
17. Return the samples to the portable refrigerator as soon as testing is completed for the day.
18. When a sample reaches 18 drops for corn and soybeans above 18% or 24 drops for all other grain types or moistures, or a greater number of drops, as specified by the jurisdiction, (specified by the jurisdictions based on data that shows that the number of drops can be increased without affecting the integrity of the grain sample), the sample must be returned to the laboratory and retested.

Look for Part 5 in this series of articles on grain moisture meters, which will address the evaluation of grain moisture meters including a review of the evaluation procedure outline contained in the Grain Moisture Meter field manual.