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What do Grain Moisture Meters Measure and How are They Calibrated?

By G. Diane Lee

Did you know that grain moisture meters do not measure moisture? Most grain moisture meters measure an electrical property, such as capacitance, related to the dielectric constant of a test cell filled with grain. Although there are other types of grain moisture meters using different technologies to predict moisture, this article addresses grain moisture meters that make use of the dielectric constant of grain to predict moisture. What is capacitance, what is a dielectric constant, and how do these relate to percent moisture? This article answers these questions, providing information on capacitance and dielectric constants, and how these measurements are used to determine the percent moisture of a grain sample and how they relate to the calibration of moisture meters.

What Grain Moisture Meters Measure

Water is a good insulator. Insulators have tightly bound electrons and can store electrical charges. A dielectric or electrical insulator is a material that is highly resistant to the flow of electrical current. Capacitance is a measure of the amount of electric charge stored (or separated) for a given electric potential. Capacitance exists between two conductors insulated from one another. A dielectric constant can be determined by measuring the capacitance of a capacitor (two conductors or plates) with air between the plates, then measuring the capacitance with a dielectric material between the plates. The ratio of these measurements is used to determine the dielectric constant.

The dielectric (capacitance) technology used in many grain moisture meters is based on the principle that a functional relationship exists between the moisture content of grain and its dielectric constant. As grain increases in moisture content (water), its dielectric constant increases. The rate at which the dielectric constant increases as grain moisture increases is not the same for all grain types; therefore, a unique calibration equation must be developed for each grain type to be measured. Moisture meters based on the dielectric principle typically incorporate a test cell in the form of an electrical capacitor, that is, two conductors separated by an insulator. When the cell is empty, only air separates the two conductors, and the insulator is air.

When a grain sample to be measured is placed between the conducting surfaces of the test cell, the grain displaces most of the air. By sensing the change in the electrical characteristics of the capacitor due to the dielectric properties of the grain sample, the meter can predict the moisture content of the sample. Because the bulk density and the temperature of the grain sample also affect the electrical characteristics of the grain-filled test cell, the meter must measure these parameters and apply the necessary corrections.

Some instruments using this method also have the capability to correct for surface moisture (conductance) effects. Year-to-year and regional changes in growing conditions and genotype variations within a single grain type can also result in changes in the

relationship between dielectric constant and moisture. These changes are effectively 'averaged out' by developing calibrations using three or more years of data representing all geographic areas.

Grain Moisture Meter Calibrations

As noted above, dielectric grain meter technology requires the use of unique calibration equations for different grains. Because meters measure the effect of moisture on certain electrical properties of grain, and because a functional relationship exists between moisture and these measured properties, a calibration equation or table can be developed that assigns a unique moisture value (air-oven reference method* moisture value) for each set of measured parameters.

To develop meter calibrations, grain samples are collected from a wide variety of moisture ranges, varieties, geographical diversities, and several crop years. Data are collected for oven moisture values, capacitance (or a related parameter), sample weight (per test-cell volume), and sample temperature. The data are evaluated and adjusted to remove outliers and to make baseline and other corrections; the data are then fitted to a calibration curve. (See Figure 1, Typical Calibration Data). Thus, measurement results obtained with a grain meter are only as good as the meter calibration. Since the calibrations are based on the data collected from a sample set of grain, if the sample grain used to test the meter is atypical (an outlier) or if a grain sample used to test the meter is not represented in the calibration sample set, the instrument may not provide accurate results on these samples when in use.

**The air-oven reference method is used to determine the reference moisture of grains. The air-oven reference method involves weighing a grain sample prior to and after a designated amount of heat is applied to the sample of grain over a specified amount of time. The grain sample is prepared (ground or air dried) prior to the oven test. Percent moisture is calculated base on the amount of weight loss in the grain sample.*

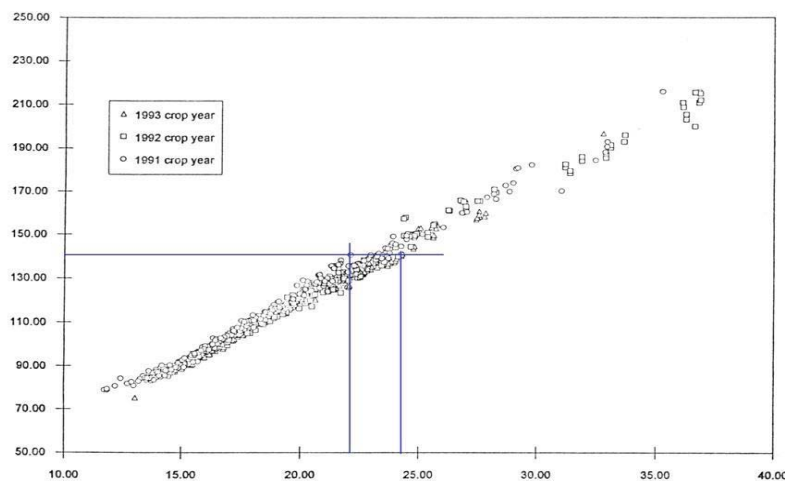


Figure 1: Typical Calibration Data 9diagram courtesy of John W. Barber, Grain Moisture Meters from Theory to Practice)

Every year States are requested to participate in providing samples to the USDA, GIPSA for the national sample set that is used to develop calibrations for NTEP grain moisture meters. The more representative the sample set used to establish the calibrations the more representative the calibrations will be. The NIST Weights and Measures Division continues to encourage States to annually submit grain samples for the national sample set.

Future articles will follow that discuss other technologies used in determining grain moisture. Contact Diane Lee of the NIST Weights and Measures Division by phone at 301-975-4405 or by e-mail at diane.lee@nist.gov for additional information concerning grain moisture measurements.