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Determining Reference Test Weight per Bushel Value of Grains

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“Test weight per bushel” is a measurement of the weight of a volume of grain required to fill level a Winchester bushel measure of 2 150.42 cubic inches (equivalent to 32 quarts) in capacity¹. Test weight per bushel is one of the measurements used by the U.S. Department of Agriculture (USDA), Grain Inspection Packers and Stockyards Administration (GIPSA) in grain grading. For example, USDA No. 1 hard red spring wheat has a minimum limit for test weight per bushel of 58.0 pounds per bushel. In the market place, test weight per bushel is a commercial measurement because it affects the market value of grain. When a farmer sells grain, the grain price may be “discounted.” If “discounted” for test weight, the farmer receives less money for the grain if the test weight per bushel measurement is under a certain specified target weight per bushel, such as 58.0 pounds per bushel. Many grain moisture meters, currently in commercial use, that are covered by a National Type Evaluation Program (NTEP) Certificate of Conformance, provide grain test weight per bushel measurements that are used to assess the amount of money a farmer will receive for grain. As such, the “test weight per bushel” measurement must be verified for accuracy. The process used to verify the accuracy of a meter’s test weight per bushel measurement begins in the laboratory. Both the NTEP laboratory and state weights and measures laboratories use a reference test weight per bushel measurement procedure, and specific equipment to determine the reference test weight per bushel values of various grains. Once a reference test weight per bushel value is determined for the grains, the grains are used to verify the accuracy of the test weight per bushel feature on meters. Both the NTEP laboratory and State Weights and Measures field inspectors verify the accuracy of the weight per bushel measurement of meters by comparing the results of the weight per bushel measurement on the meter to the reference “test weight per bushel” value of the grain samples that are placed in the meter for measurement. This article addresses the laboratory equipment, equipment maintenance, and reference procedures for test weight per bushel because of its importance in determining the accuracy of the test weight per bushel measurement of meters.

¹ Circular No. 921 U.S. Department of Agriculture, June 1953

Equipment

To determine reference test weight per bushel measurements of grain, use test weight per bushel equipment approved by USDA, GIPSA. The USDA, GIPSA Equipment Handbook includes two lists of GIPSA approved equipment: active and inactive. The active equipment list includes GIPSA approved equipment that is commercially available. The inactive equipment list contains GIPSA approved equipment no longer manufactured or widely marketed, but is still approved for use. The equipment used to determine reference test weight per bushel values for grain are:

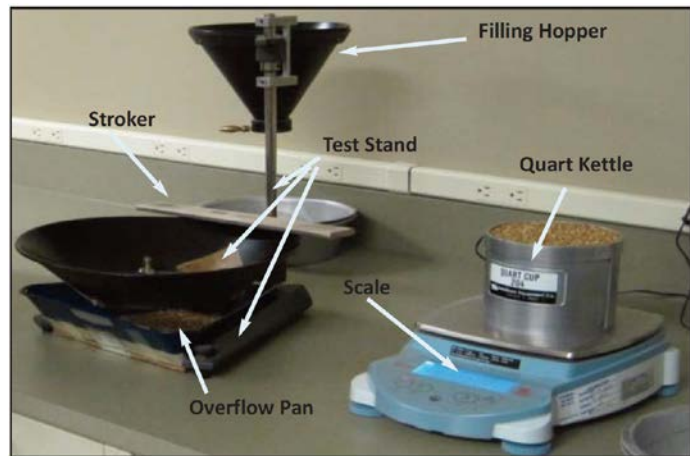


Figure 1. Test Weight per Bushel Equipment - Active Approved Equipment

- a quart kettle,
- a scale specifically designed to measure test weight per bushel,
- a filling hopper,
- an over flow pan, and
- a stroker.

Figure 1 includes test weight per bushel equipment from GIPSA's active approved equipment list and currently in use at the USDA, GIPSA in Kansas City, Missouri.

Equipment Maintenance

The test weight per bushel equipment must be checked and adjusted prior to initial use; and periodically, thereafter, as needed. A maintenance schedule of the checks and adjustments made to the equipment must be documented. The specifications and maintenance for test weight per bushel equipment are included in GIPSA's Equipment Handbook, which can be downloaded from the USDA, GIPSA Website [at http://www.gipsa.usda.gov/Publications/fgis/handbooks/equip_inspbh.html](http://www.gipsa.usda.gov/Publications/fgis/handbooks/equip_inspbh.html).

Procedure for Determining the Reference Test Weight per Bushel Value of Grains

In general, the procedure used to determine the reference test weight per bushel of grain is to weigh one dry quart of the grain on a suitable scale that is designed to multiply the weight by 32, since there are exactly 32 quarts to a dry bushel. These specially designed scales provide a direct reading of test weight per bushel. Since these scales indicate 32 times the weight of the content in the dry quart, it is very important to follow procedures for determining the reference test weight per bushel values of grain.

The following is a step by step procedure to determine the reference test weight per bushel values of grain samples that are used to test meters or other



Figure 2. Zero weight of the empty quart kettle.

equipment used to provide test weight per bushel measurements to customers in the marketplace.

1. Before starting the procedure, ensure that the equipment is positioned correctly by placing a level on top of the quart kettle to ensure that it is in a level condition on the test stand and position the filling hopper two inches above the top of the quart kettle. Procedures for measuring this distance are included in Chapter 5 of the USDA GIPSA Equipment Handbook.
2. Place the empty quart kettle on the scale; then zero the scale (Figure 2).
3. Close the bottom of the fill hopper; place about $1\frac{1}{8}$ quart of grain in the filling hopper, and place the quart kettle on the test stand.
4. Position the fill hopper over the quart kettle by swiveling the fill hopper and fill the kettle from the hopper (Figure 3). Do not move the kettle while it is being filled.
5. Once the quart kettle is full, move the fill hopper away from the quart kettle being careful not to move the kettle.

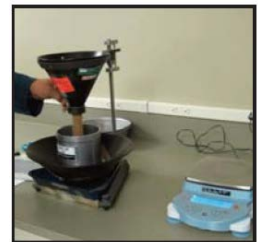


Figure 3. Filling the quart kettle from the filling hopper.



Figure 3a. Remove excess grain.

6. Hold the stoker on each end with your fingers so that the sides are in a vertical position and place it lightly on the edge of the kettle without moving the kettle (Figure 3a).

7. Stroke the excess grain from the top of the quart kettle in a zigzag motion with three full strokes. Each stroke should cover $\frac{1}{3}$ of the top of the kettle (Figure 3b).

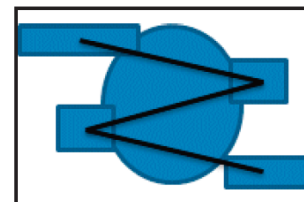


Figure 3b. Stroke pattern: Start with the stoker at the edge of the quart kettle and follow a zigzag pattern.

Important Note: Scales used to measure test weight per bushel are specially designed to provide an indication that is 32 times the weight of the grain in the quart kettle. So, if the quart kettle contains 1 pound, then the scale will show a weight per bushel indication of 32 pounds per bushel (1 to 32 ratio). It is extremely important to follow the procedure for step 6, stroking excess grain from the quart kettle because too much or too little grain removed, will impact the measurement by a multiple of 32 (e.g., if 1 ounce of grain is removed that should have been part of the measurement there will be a 2.0 pounds per bushel error in the test weight per bushel measurement).



Figure 4. Weighing the quart kettle and grain.

8. Carefully remove the quart kettle from the stand and weigh the kettle and grain on the scale and record your results. (See figure 4.)

Example of calculation:

$$1 \text{ lb} = 16 \text{ oz}$$

$$1 \text{ oz}/16 \text{ oz} = 0.0625 \text{ lb, so, } 0.0625 \text{ lb} \times 32 = 2.0 \text{ lb}$$

In accordance with the National Institute of Standards and Technology (NIST) Handbook (HB) 44, *Specifications, Tolerances, and Other Technical Requirements for Weighing and Measuring Devices*, Section 5.56.(a) Grain Moisture Meters, paragraph N.1.1. Air Oven Reference Method Transfer Standards, repeat steps 1 through 8, 10 times and average the results for each grain type. The test weight per bushel value assigned to the grain samples is the average of 10 measurements. When assigning this value, it must be noted that when a standard is used without correction, the combined error and uncertainty in your measurement must be less than one-third of the applicable tolerances, in accordance with NIST HB 44, Appendix A. Fundamental Considerations, Section 3.2. Tolerances for Standards.

The consistent use of proper techniques and proper equipment is key to successfully determining the reference values for test weight per bushel.

Using the prescribed test procedures and correct equipment, as provided in this article along with maintaining your equipment in accordance with the USDA, GIPSA Equipment Handbook will reduce the variability and error in your reference test weight per bushel measurements made in the laboratory. Practice removing the excess grain from the quart kettle will result in better measurement repeatability. Additionally, grain samples with accurate weight per bushel values will help to ensure proper testing of meter weight per bushel measurements.

RESOURCES FOR TEST WEIGHT PER BUSHEL REFERENCE MEASUREMENTS

- USDA, GIPSA Equipment Handbook at:
http://www.gipsa.usda.gov/Publications/fgis/handbooks/equip_insphb.html.
- Circular No. 921 "The Test Weight per Bushel of Grain: Methods of Use and Calibration of the Apparatus," June 1953, United States Department of Agriculture.

For additional information concerning this article you may contact Diane Lee of the NIST, Office of Weights and Measures (OWM) by e-mail at diane.lee@nist.gov, or contact the office at owm@nist.gov, phone (301) 975-3998.

Note: It is policy of the National Institute of Standards and Technology to use metric units of measurement in all of its publications. However, in this newsletter the references to inch-pound units are used as they are commonly used in industry practice and in source documentation.

Editor's Note: Labeling on Figure 1 corrected.