New Official Moisture Technology

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Federal Grain Inspection Service
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History of Official Moisture Meter Approvals

• 1937 – Tag-Heppenstall
• 1960 - Motomco Model 919
• 1998 - Dickey-john GAC 2100
• April 11, 2012 – First UGMA-Compatible moisture meters approved
  — DICKEY-john GAC 2500UGMA
  — Perten AM 5200-A.
GIPSA-Certified UGMA-Compatible Moisture Meters

Dickey-john GAC 2500UGMA  Perten AM 5200-A
What is GIPSA’s Unified Grain Moisture Algorithm (UGMA)?

- Very accurate dielectric-type moisture method
- Higher measurement frequency (about 150 MHz)
- Based on a defined physical parameter—Dielectric Constant
- Excellent density correction
- Three “unifying parameters” per grain group
- A single calibration “curve” for all grain types
- Precise, wide-range temperature correction
- Calibrated to GIPSA’s standard Air Oven method
- “Open”—Available to any manufacturer
Eureka! #1: Effectiveness of the Landau-Lifshitz, Looyenga Density Correction

LLL_Exponent = 0
SEC = 1.396

Density Correction--Corn @ 149 MHz

Air Oven Moisture (%wb) vs. Density-Corr. Dielectric Constant
Eureka! #2: Geometrically-Similar Shapes in VHF Range
Landau-Lifshitz, Looyenga
Density Normalization
Adjust Slope Parameter for Slope of 6.0 %M per unit dielectric constant in 10-20 % Range
Adjust Offset Parameter
Adjust Translation Parameter
5\textsuperscript{th}-Order Polynomial Equation

Number of Samples = 6189
Overall SEC = 0.34 % Moisture
Unified Grain Moisture Algorithm

- **Grain Sample**
  - **Z⁺ or Γ⁺ Sensor**
  - **Density Correction**
  - **Unifying Parameters**
  - **Temperature Correction**
  - **Moisture Result**

- **Instrument Parameters**
  - **Mass Sensor**
  - **Sample Corrections**
  - **Secondary Corrections**

- **Test Cell Parameters**
  - **Cell Volume**
  - **Z, d, etc.**

- **Polynomial Coefficients**

- **User**
  - **Manufacturer**
  - **GIPSA**

- **SFG or ABCD Model**

- **Density Correction**
  - **εdensity corrected**

- **Unifying Parameters**
  - **εunified**

- **Temperature Correction**
  - **%M**

- **Temp. Corr. Parameters**
  - **GROUP ID**

- **Type-Group Table**

- **Instrument Parameters**
  - **Effective**

- **D.B. Funk**
  - **November 9, 2006**
Why change to UGMA?
Improved Accuracy for All Grain Types

2011 Corn Crop

GAC 2100

UGMA
Improved Accuracy of UGMA

The graph shows the variability (SDD % Moisture) for different crops compared to air oven readings. The crops include Corn, Soybeans, Sorghum, Sunflower, Rice (Long Rough), and Rice (Medium Rough). Two methods are compared: GAC 2100 vs. Air Oven and UGMA Master vs. Air Oven.
Improved Accuracy of UGMA

The graph shows the variability in percent moisture for different types of grains compared to a reference. The categories include:
- Wheat, Hard
- Wheat, Red
- Wheat, Winter
- Durum
- Barley
- Oats

The graph compares two methods:
- GAC 2100 vs. Air Oven
- UGMA Master vs. Air Oven
Improved Year-to-Year Calibration Stability
Corn

GAC 2100

UGMA

FEDERAL GRAIN INSPECTION SERVICE
Sunflower

GAC 2100

UGMA

Legend: 1 yr, 3 yr
Soft Red Winter Wheat

GAC 2100

UGMA

1 yr

3 yr
Drastically Improved Accuracy on High and Low Test Weight Corn
GAC 2100 Corn Results—Density Issue
Accuracy for 2007-2009 Crops

For range: 10-36% M
Samples: 686
Std. Dev. of Diff: 0.70% M

Low TW samples yielded low moisture results.
The drastic change in test weight with moisture for normal corn presents special challenges for density correction of corn moisture measurements.
## Secondary Density Correction
Corn Results for UGMA

<table>
<thead>
<tr>
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<th>Before</th>
<th>After</th>
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</thead>
<tbody>
<tr>
<td><strong>Bias</strong></td>
<td>-0.04</td>
<td>-0.01</td>
</tr>
<tr>
<td><strong>STD</strong></td>
<td>0.46</td>
<td>0.31</td>
</tr>
<tr>
<td><strong>Slope</strong></td>
<td>-0.01</td>
<td>-0.01</td>
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### All Samples

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<tbody>
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<td><strong>Bias</strong></td>
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<td><strong>STD</strong></td>
<td>0.34</td>
<td>0.32</td>
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<tr>
<td><strong>Slope</strong></td>
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<td>-0.03</td>
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### Normal

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<tbody>
<tr>
<td><strong>Bias</strong></td>
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<td>0.01</td>
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<tr>
<td><strong>STD</strong></td>
<td>0.36</td>
<td>0.30</td>
</tr>
<tr>
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### Low Density

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**Air Oven Moisture, %M**

**Moisture Prediction Error, %M**

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**Before Correction**

**After Correction**

+++ Normal Corn

红circle Low Density Corn

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**Federal Grain Inspection Service**
Wider Sample Temperature Ranges

GAC 2100

32 °F

103 °F

113 °F

0 °F

UGMA Meters
"Green" Grain Effects Reduced

Long Grain Rough Rice Rebound

Moisture Error due to Rapid Drying (%)

Moisture Content of the Dried Sample, M %
“Green” Grain Effects Reduced

LGRR Mixture Effects

Error due to Mixture of Wet and Dry Rice (%)

Moisture Content of the Wet Component, M %

GAC 2100
UGMA
“Green” Grain Effects Reduced

Effects of Mixtures of Wet and Dry Soybeans

Moisture Error due to Mixture (%)

Moisture of Wet Component of Mixture (%)

+ + + GAC 2100
O O O UGMA

USDA
GIPSA’s Basic Definition of Equivalency

• Same technology
• Very close agreement among types as well as units of a type
• Same calibrations and standardization processes
UGMA-Compatibility Criteria (1)

- NTEP Certification
- Documented & stable production processes
- Measurement frequency
- Standardized test cell design
- Standardized loading method
- Standardized measurements
  - Sample dielectric constant
  - Sample mass
  - Sample temperature
UGMA-Compatibility Criteria (2)

• Tight tolerances specified for individual subsystems as well as moisture results
• Must use specified mathematics
• Units’ agreement with FGIS Master system must meet tolerances in FGIS Regulations
  – +/- 0.05% M for Headquarters Standard units
  – +/- 0.15% M for other Official units
  – Mean difference on medium-moisture HRWW
UGMA-Compatibility Criteria (3)

• All UGMA-Compatible models must be able to use the same check testing process.

• A simple check testing process must ensure performance on all grains over full moisture ranges.

• Instruments must provide for efficient means of entering calibrations.

• Instruments must provide standardized output data stream for printing or networking.
Excellent Agreement Between UGMA Models

![Graph showing variability in percent moisture for different crops and models.](image)
Excellent Agreement Between UGMA Models

Check Testing Tolerance for Official Moisture Meters

Variability (SDD %Moisture)

- Wheat, Hard
- Wheat, Hard Red
- Wheat, Hard Red Winter
- Wheat, Soft Red
- Wheat, Soft White
- Wheat, Soft Winter
- Durum
- Barley
- Oats

GAC2500 vs AM5200
UGMA Unit to Unit
Far Better Agreement Than Between Different Technologies
Far Better Agreement Than Between Different Technologies
UGMA Moisture Meter Implementation Schedule

September 1, 2012
• Corn
• Soybeans
• Sorghum
• Sunflower

May 1, 2013
• Wheat
• Barley
• Oats
• Rice (Rough and Processed)
• Edible Beans, Peas, Lentils
• Canola, Rapeseed, Mustard
• Flaxseed
• Safflower
• Triticale and Rye
Anticipated Moisture Changes with Transition to UGMA

- GAC 2100 and new UGMA –based meters are all calibrated to agree with GIPSA’s air oven method as closely as possible.
- Do not expect significant average differences between GAC 2100 and new UGMA-based meters—except:
  - Low test weight corn moisture values will generally increase:
    - GAC 2100 reads lower than UGMA by 0.2% per pound per bushel below 57 lb/bu
  - High test weight corn moisture values will generally decrease:
    - GAC 2100 reads higher than UGMA by 0.2% per pound per bushel above 57 lb/bu