Updating the Pack Factor for Calculation of Bushels from Volumetric Measurements

Research under an interagency agreement between USDA-ARS and USDA-RMA

Collaborating Institutions
USDA-ARS-CGAHR
Kansas State University
University of Kentucky
University of Georgia
Research Team

Mike Montross
Univ. of Kentucky

Sam McNeill

Mark Casada, USDA-ARS-CGAHR
Ronaldo Maghirang, Rumela Bhadra, & Josephine Boac, Kansas State Univ.

Sid Thompson
Univ. of Georgia
What is Pack Factor?

- Pack factor - an adjustment factor used to accurately determine weight of grain stored in a grain bin
  - use grain volume measurements
  - accounts for the overbearing pressure of grain above

- Also called “Pack,” “Packing factor,” or “Compaction”

- Different impacts of pack factor on operations:
  - Grain Elevators
  - On-Farm Bins
What is Pack Factor?

- **Grain Elevators:**
  - Important for accurate grain inventory
    - Internal use – Quality Management Systems
    - Auditing – state or federal warehouse officials
    - Loan collateral

- **On-Farm Bins:**
  - Important for insurance or loan purposes (RMA and FSA county offices)
Project Objectives

- Develop new stored grain pack factors for six grains: wheat, corn, soybean, sorghum, oats, and barley
- Obtain nationwide field data of pack factors in a wide range of bin sizes (small farm bin sizes up to Million bushel bins) along with laboratory compaction data
- Incorporate new pack factors into a user-friendly, windows-based software package for use by the grain industry
General Trends on Packing Effects*

- Doubling the grain height
  - Increase pack factor by 0.5 - 1.2 %

- Doubling the bin diameter
  - Increase pack factor by 0.2 - 0.3 %

- Increasing the moisture by 3-6%
  - Increase pack factor by 0.20 - 0.90 %

* Research from ASAE journals. The test crops were Wheat, Corn and Soybeans
Laboratory Compressibility Tester

University of Kentucky
Granular Mechanics Laboratory

Fill the tester with grain

Compress the grain by applying pressure
Compressibility of Corn from Lab Measurements

Note: Red dots may represent field measurements.
Field Measurements

- Wide range of upright bin sizes, types
- Six grains: wheat, corn, soybean, sorghum, oats, and barley
- All major grain-producing locations within the U.S. emphasizing the:
  - Midwest,
  - Southern Mississippi River valley,
  - Central Plains,
  - Northern Plains.
- Expected locations for some crops illustrated next:
Potential Location for Field Measurement – Wheat

Wheat production by county

Bushels
- Not Estimated
- < 1,000,000
- 1,000,000 - 4,999,999
- 5,000,000 - 9,999,999
- 10,000,000 - 14,999,999
- 15,000,000 - 19,999,999
- 20,000,000 +

U.S. Department of Agriculture, National Agricultural Statistics Service
Potential Location for Field Measurement – Corn

Corn for grain production by county

U.S. Department of Agriculture, National Agricultural Statistics Service
Data to be Measured/Collected

- Grain type, Test weight, Moisture content
- Grain height (where grain intersects bin wall)
- Bin dimensions and Cone configuration
- Weight of grain at given depths (in lbs)
- Bin wall material
- Method used to fill bin
- Aeration practice
Measurement Procedures

- **On-Farm Bins**
  - Measure bin dimensions and grain volume
  - Collect weights and grain property data after the crop is sold

- **Grain Elevators**
  - Measure bin dimensions and grain volume
  - Collect weights and grain property data while incoming trucks are being unloaded
Equipment/Laser Holder

Laser meter

Leica Disto D8 (laser meter mounted on digital protractor)
Commercial & On-Farm Bins
## Bins Measured To Date

<table>
<thead>
<tr>
<th>Year</th>
<th>Crop</th>
<th>Total No. of Bins</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010</td>
<td>Corn</td>
<td>4</td>
</tr>
<tr>
<td>2010</td>
<td>Wheat*</td>
<td>15</td>
</tr>
<tr>
<td>2011</td>
<td>Corn**</td>
<td>29</td>
</tr>
<tr>
<td>2011</td>
<td>Wheat</td>
<td>32</td>
</tr>
<tr>
<td>2011</td>
<td>Sorghum**</td>
<td>4</td>
</tr>
<tr>
<td>2011</td>
<td>Oats</td>
<td>12</td>
</tr>
<tr>
<td>2011</td>
<td>Soybean**</td>
<td>12</td>
</tr>
</tbody>
</table>

**TOTAL 108**

* For wheat, the dockage range was 0.30 – 1.0 %.  
**Waiting for grain properties for bins already measured.
To Date: Field Locations Visited
## Bins Measured To Date

<table>
<thead>
<tr>
<th></th>
<th>Wheat On-Farm Bins</th>
<th>Elevators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pack Factor (%)</td>
<td>2.9 – 7.7</td>
<td>3.4 – 8.1</td>
</tr>
<tr>
<td>Moisture (% db)</td>
<td>10 – 13</td>
<td>10 – 13</td>
</tr>
<tr>
<td>Test Weight (lb/bu)</td>
<td>58 – 64</td>
<td>53 – 62</td>
</tr>
<tr>
<td>Bin Diameter (ft)</td>
<td>15 – 54</td>
<td>15 – 105</td>
</tr>
<tr>
<td>Grain Height (ft)</td>
<td>3.4 – 26</td>
<td>18 – 136</td>
</tr>
<tr>
<td>Total No. of Bins</td>
<td>13</td>
<td>34</td>
</tr>
<tr>
<td>States</td>
<td>KS and KY</td>
<td>OK and KS</td>
</tr>
</tbody>
</table>
## Bins Measured To Date

<table>
<thead>
<tr>
<th></th>
<th>Corn On-Farm Bins and Elevators</th>
<th>Oats Elevators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pack Factor (%)</td>
<td>2.7 – 8.0</td>
<td>19 – 33</td>
</tr>
<tr>
<td>Moisture (% db)</td>
<td>13 – 17</td>
<td>12 – 13</td>
</tr>
<tr>
<td>Test Weight (lb/bu)</td>
<td>55 – 58</td>
<td>39 – 43</td>
</tr>
<tr>
<td>Bin Diameter (ft)</td>
<td>12 – 105</td>
<td>22 – 90</td>
</tr>
<tr>
<td>Grain Height (ft)</td>
<td>8.6 – 97</td>
<td>46 – 99</td>
</tr>
<tr>
<td>Total No. of. Bins</td>
<td>33 (13 finalized)*</td>
<td>12</td>
</tr>
<tr>
<td>States</td>
<td>KY, OK, IA, CO, KS and MN</td>
<td>NE and MN</td>
</tr>
</tbody>
</table>

* Waiting for grain properties for 20 bins (for corn) already measured.
## Bins Measured To Date

<table>
<thead>
<tr>
<th></th>
<th>Soybean</th>
<th>Sorghum</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elevators</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pack Factor (%)</td>
<td>3.2 – 4.7</td>
<td>4.1 – 5.6</td>
</tr>
<tr>
<td>Moisture (% db)</td>
<td>8.5 – 11</td>
<td>13 – 15</td>
</tr>
<tr>
<td>Test Weight (lb/bu)</td>
<td>58 – 59</td>
<td>56 – 58</td>
</tr>
<tr>
<td>Bin Diameter (ft)</td>
<td>42 – 75</td>
<td>14.95 – 14.99</td>
</tr>
<tr>
<td>Grain Height (ft)</td>
<td>16 – 73</td>
<td>4.6 – 81</td>
</tr>
<tr>
<td>Total No. of Bins</td>
<td>12 (5 finalized)*</td>
<td>4 (3 finalized)*</td>
</tr>
<tr>
<td>States</td>
<td>SD and MN</td>
<td>OK</td>
</tr>
</tbody>
</table>

* Waiting for grain properties for 7 bins (for soybeans) and 1 bin (for sorghum) already measured.
## Small vs. Large Bins

### Crop: Corn

<table>
<thead>
<tr>
<th>Properties</th>
<th>Small Bin</th>
<th>Large Bin</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Height (ft)</td>
<td>8.6</td>
<td>97</td>
</tr>
<tr>
<td>Bin Diameter (ft)</td>
<td>18</td>
<td>105</td>
</tr>
<tr>
<td>Test Weight (lb/bu)</td>
<td>55</td>
<td>55</td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>15.5</td>
<td>15</td>
</tr>
<tr>
<td>Pack Factor (%)</td>
<td>2.7</td>
<td>6.6</td>
</tr>
</tbody>
</table>
Effects of Additional Variables

Variable: Moisture Content
Crop: Wheat

Variable: Grain Height
Crop: Wheat

<table>
<thead>
<tr>
<th>Properties</th>
<th>Short Grain Height</th>
<th>Tall Grain Height</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Height (ft)</td>
<td>37.5</td>
<td>127.5</td>
</tr>
<tr>
<td>Bin Diameter (ft)</td>
<td>14.95</td>
<td>14.95</td>
</tr>
<tr>
<td>Test Weight (lb/bu)</td>
<td>61</td>
<td>61</td>
</tr>
<tr>
<td>Moisture Content (%)</td>
<td>11.6</td>
<td>11.6</td>
</tr>
<tr>
<td>Pack Factor (%)</td>
<td>3.4</td>
<td>4.3</td>
</tr>
</tbody>
</table>
Field Locations

Legend:
- Measured
- Scheduled
- Additional Locations Needed
More Field Locations

Thank you.

Questions?

Contact:  Dr. Josephine M. Boac, Research Associate
          Biological and Agricultural Engineering
          Kansas State University
          c/o USDA-ARS CGAHR EWERU
          1515 College Ave. Manhattan, KS 66502
          Phone: 785-776-2768, 785-317-7998
          Email: jmboac@k-state.edu