Grain Handling, Drying and Storage Management

Michael J. Buschermohle
Biosystems Engineering and Soil Science
Grain Handling, Drying and Storage Management

What Affects Grain Quality

- Grain Handling
- Grain Drying
- Grain Storage Management
- Grain Bin Safety
Poor Grain Quality Costs You Money

- Decreased germination
- Weight loss
- Mycotoxins
- Price discounts
What Affects Grain Quality

- Condition of the grain
- Grain moisture content
- Grain temperature
Condition of the Grain

- Degree which mold is invaded
- Foreign matter and broken kernels
## Allowable Storage Time (Days) for Soybeans

<table>
<thead>
<tr>
<th>Storage Air Temperature °F</th>
<th>11%</th>
<th>12%</th>
<th>13%</th>
<th>14%</th>
<th>15%</th>
<th>16%</th>
<th>17%</th>
</tr>
</thead>
<tbody>
<tr>
<td>30</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>&gt;300</td>
</tr>
<tr>
<td>40</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>280</td>
<td>200</td>
<td>140</td>
<td>90</td>
</tr>
<tr>
<td>50</td>
<td>&gt;300</td>
<td>&gt;300</td>
<td>230</td>
<td>130</td>
<td>90</td>
<td>70</td>
<td>50</td>
</tr>
<tr>
<td>60</td>
<td>&gt;300</td>
<td>240</td>
<td>120</td>
<td>75</td>
<td>50</td>
<td>35</td>
<td>25</td>
</tr>
<tr>
<td>70</td>
<td>200</td>
<td>125</td>
<td>70</td>
<td>45</td>
<td>30</td>
<td>20</td>
<td>14</td>
</tr>
<tr>
<td>80</td>
<td>140</td>
<td>70</td>
<td>40</td>
<td>20</td>
<td>15</td>
<td>10</td>
<td>7</td>
</tr>
</tbody>
</table>
# Allowable Storage Time (Days) for Corn

<table>
<thead>
<tr>
<th>Storage Air Temperature °F</th>
<th>Moisture Content %</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>15%</td>
<td>20%</td>
</tr>
<tr>
<td></td>
<td>Days</td>
<td>Days</td>
</tr>
<tr>
<td>35</td>
<td>1140</td>
<td>118</td>
</tr>
<tr>
<td>40</td>
<td>906</td>
<td>94</td>
</tr>
<tr>
<td>45</td>
<td>725</td>
<td>75</td>
</tr>
<tr>
<td>50</td>
<td>466</td>
<td>48</td>
</tr>
<tr>
<td>55</td>
<td>337</td>
<td>35</td>
</tr>
<tr>
<td>60</td>
<td>259</td>
<td>27</td>
</tr>
<tr>
<td>65</td>
<td>207</td>
<td>21.5</td>
</tr>
<tr>
<td>70</td>
<td>155</td>
<td>16.1</td>
</tr>
<tr>
<td>75</td>
<td>116</td>
<td>12.1</td>
</tr>
</tbody>
</table>
Grain Handling, Drying and Storage Management

- What Affects Grain Quality
- Grain Handling
- Grain Drying
- Grain Storage Management
- Grain Bin Safety
Handling

Severity of mechanical damage depends on

- Seed moisture content
- Velocity of impact
- Hardness of impacted surface
Proper Handling

- Avoiding excessive impact of the grain on hard surfaces;
- Running conveyors as full and as slow as possible to maintain capacity;
- Using retarder boxes in chutes with long drops (>40 ft) to slow the soybeans and lessen the impact.
Grain Handling, Drying and Storage Management

- What Affects Grain Quality
- Grain Handling
- Grain Drying
- Grain Storage Management
- Grain Bin Safety
What Influences Grain Drying

• Air Temperature and Relative Humidity

• Airflow Rate
# Influence of Air Properties on Drying

## Equilibrium Moisture Content for Soybeans

<table>
<thead>
<tr>
<th>Temp °F</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>6.4</td>
<td>7.7</td>
<td>9.3</td>
<td>11.3</td>
<td>14.2</td>
<td>18.9</td>
</tr>
<tr>
<td>50</td>
<td>6.3</td>
<td>7.6</td>
<td>9.1</td>
<td>11.1</td>
<td>14.0</td>
<td>18.6</td>
</tr>
<tr>
<td>60</td>
<td>6.2</td>
<td>7.4</td>
<td>8.9</td>
<td>10.9</td>
<td>13.7</td>
<td>18.3</td>
</tr>
<tr>
<td>70</td>
<td>6.1</td>
<td>7.3</td>
<td>8.8</td>
<td>10.7</td>
<td>13.5</td>
<td>17.9</td>
</tr>
<tr>
<td>80</td>
<td>5.9</td>
<td>7.1</td>
<td>8.6</td>
<td>10.5</td>
<td>13.2</td>
<td>17.6</td>
</tr>
<tr>
<td>90</td>
<td>5.8</td>
<td>7.0</td>
<td>8.4</td>
<td>10.3</td>
<td>13.0</td>
<td>17.3</td>
</tr>
<tr>
<td>100</td>
<td>5.7</td>
<td>6.9</td>
<td>8.3</td>
<td>10.1</td>
<td>12.7</td>
<td>17.0</td>
</tr>
</tbody>
</table>
## Influence of Air Properties on Drying

### Equilibrium Moisture Content for Soybeans

<table>
<thead>
<tr>
<th>Temp °F</th>
<th>30</th>
<th>40</th>
<th>50</th>
<th>60</th>
<th>70</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>6.4</td>
<td>7.7</td>
<td>9.3</td>
<td>11.3</td>
<td>14.2</td>
<td>18.9</td>
</tr>
<tr>
<td>50</td>
<td>6.3</td>
<td>7.6</td>
<td>9.1</td>
<td>11.1</td>
<td>14.0</td>
<td>18.6</td>
</tr>
<tr>
<td>60</td>
<td>6.2</td>
<td>7.4</td>
<td>8.9</td>
<td>10.9</td>
<td>13.7</td>
<td>18.3</td>
</tr>
<tr>
<td>70</td>
<td>6.1</td>
<td>7.3</td>
<td>8.8</td>
<td>10.7</td>
<td>13.5</td>
<td>17.9</td>
</tr>
<tr>
<td>80</td>
<td>5.9</td>
<td>7.1</td>
<td>8.6</td>
<td>10.5</td>
<td>13.2</td>
<td>17.6</td>
</tr>
<tr>
<td>90</td>
<td>5.8</td>
<td>7.0</td>
<td>8.4</td>
<td>10.3</td>
<td>13</td>
<td>17.3</td>
</tr>
<tr>
<td>100</td>
<td>5.7</td>
<td>6.9</td>
<td>8.3</td>
<td>10.1</td>
<td>12.7</td>
<td>17.0</td>
</tr>
</tbody>
</table>
Average Monthly Air Temperature and Relative Humidity
## Influence of Air Properties on Drying

### Equilibrium Moisture Content for Corn

<table>
<thead>
<tr>
<th>Temp °F</th>
<th>20</th>
<th>40</th>
<th>60</th>
<th>80</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>9.2</td>
<td>11.9</td>
<td>14.5</td>
<td>17.9</td>
</tr>
<tr>
<td>50</td>
<td>8.5</td>
<td>11.2</td>
<td>13.8</td>
<td>17.3</td>
</tr>
<tr>
<td>60</td>
<td>7.9</td>
<td>10.6</td>
<td>13.3</td>
<td>16.8</td>
</tr>
<tr>
<td>70</td>
<td>7.3</td>
<td>10.0</td>
<td>12.7</td>
<td>16.3</td>
</tr>
<tr>
<td>80</td>
<td>6.7</td>
<td>9.6</td>
<td>12.3</td>
<td>15.9</td>
</tr>
<tr>
<td>90</td>
<td>6.3</td>
<td>9.1</td>
<td>11.9</td>
<td>15.5</td>
</tr>
<tr>
<td>100</td>
<td>5.8</td>
<td>8.7</td>
<td>11.5</td>
<td>15.1</td>
</tr>
</tbody>
</table>
Safe Maximum Drying Temperature and Humidity

Drying Temperatures

- Soybeans used for seed: 85 - 100 °F
- Soybeans used for oil and food production: 130 °F

Air Relative Humidity

- > 40%

Air relative humidity is roughly cut in half with each 20 increase in air temperature
### Safe Maximum Drying Temperature

<table>
<thead>
<tr>
<th>Use</th>
<th>Operating Plenum Temperature °F</th>
<th>Maximum Grain Temperature °F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Food Corn</td>
<td>130 - 140</td>
<td>100</td>
</tr>
<tr>
<td>Wet Milling Corn</td>
<td>170 - 190</td>
<td>130</td>
</tr>
<tr>
<td>Livestock Feed</td>
<td>170 - 190</td>
<td>130</td>
</tr>
</tbody>
</table>
Influence of Air Properties on Drying

- Air Temperature and Relative Humidity
- Airflow Rate
Minimum Airflow Rates for Drying Soybeans

<table>
<thead>
<tr>
<th>Moisture Content</th>
<th>Minimum Airflow Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>18 to 20%</td>
<td>3.0</td>
</tr>
<tr>
<td>15 to 18%</td>
<td>2.0</td>
</tr>
<tr>
<td>13 to 15%</td>
<td>1.0</td>
</tr>
<tr>
<td>11 to 13%</td>
<td>.5</td>
</tr>
</tbody>
</table>
Drying Fan Performance

- Airflow cfm/bu
- Grain Depth ft
- 5 HP Fan
Natural Air or Low Temperature Drying Systems

System Requirements

• Airflow Rate: 1 to 3 cfm/bu
• Supplemental heat: <10 °F

Advantages

• Lower Drying Cost

Disadvantages

• Initial Moisture Content Limits
• Slow Drying
In-Bin Deep Batch Drying

System Requirements

• Drying Depth: 7 to 9 feet layer
• Airflow Rate: 1 to 3 cfm/bu
• Drying Air Temperature: 85 to 100 °F
<table>
<thead>
<tr>
<th>What Affects Grain Quality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Grain Handling</td>
</tr>
<tr>
<td>Grain Drying</td>
</tr>
<tr>
<td>Grain Storage Management</td>
</tr>
<tr>
<td>Grain Bin Safety</td>
</tr>
</tbody>
</table>
Grain Storage Management

Grain Storage *Never* Improves Grain Quality
S.L.A.M. Post Harvest Management Strategy

- Sanitation
- Loading
- Aeration
- Monitoring
Sanitation

• Remove old grain from combines, truck beds, augers and any other equipment used for harvesting, transporting or handling grain.

• Remove any spilled grain, weeds and tall grass around bins to reduce the likelihood of rodent or insect infestations.
Sanitation

• Inspect bin roofs and sides, inside and out, for cracks, loose or missing bolts, and rust and repair if necessary.

• Clean grain storage facilities thoroughly before filling to eliminate existing insect and mold problems.
Sanitation

- After cleaning and repairing grain bins, sanitize the walls, floors, under floors and roof areas inside and out with an approved residual insecticide.

Publication PB-1395 “Insects in Farm- Stored Grain”
S.L.A.M. Post Harvest Management Strategy

- Sanitation

- Loading

- Aeration

- Monitoring
Loading

- Clean the grain before loading into storage bins
- Never mix new grain with old grain!
- Know the grain moisture content going into storage
Managing trash and fines.
Loading

- Manage trash and fines
  - Core the fines and trash from the center of the grain
Loading

- Don’t overfill the bin
Loading

- Level peaked grain soon after harvest
Loading

- Leveling peaked grain
  - Unloading the center core
  - Grain spreaders
  - By hand
S.L.A.M. Post Harvest Management Strategy

- Sanitation
- Loading
- Aeration
- Monitoring
Aeration

- Prevents or reduces quality loss of stored grain
- Prevents moisture migration
Aeration

Winter Moisture Migration
Aeration

Winter Moisture Migration
Aeration

Summer Moisture Migration
Aeration

What is Aeration?
Aeration

Aeration Cooling Cycles
Aerate Grain to Prevent Storage Problems

Keep Grain Temperature to Within 10 to 15 °F of Average Monthly Air Temperature

- Insect Reproduction Reduced
- Insects Dormant
- Insects Killed

Optimum for Insects and Spoilage
## Aeration Management

### Typical Aeration Time (Hours)

<table>
<thead>
<tr>
<th>CFM/bu</th>
<th>Grain Condition</th>
<th>Time (hours)</th>
<th>Aeration Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Clean</td>
<td>High F.M.</td>
<td></td>
</tr>
<tr>
<td>.1</td>
<td>120</td>
<td>150-175</td>
<td>Light</td>
</tr>
<tr>
<td>.2</td>
<td>60</td>
<td>75-85</td>
<td>Medium</td>
</tr>
<tr>
<td>.4</td>
<td>30</td>
<td>35-40</td>
<td>Medium</td>
</tr>
<tr>
<td>.6</td>
<td>24</td>
<td>25-30</td>
<td>Fast</td>
</tr>
<tr>
<td>.8</td>
<td>15</td>
<td>18-20</td>
<td>Fast</td>
</tr>
<tr>
<td>1</td>
<td>12</td>
<td>14-16</td>
<td>High Speed</td>
</tr>
<tr>
<td>2</td>
<td>6</td>
<td>8-10</td>
<td>High Speed</td>
</tr>
<tr>
<td>3</td>
<td>4</td>
<td>5-6</td>
<td>High Speed</td>
</tr>
<tr>
<td>5</td>
<td>2.5</td>
<td>3-4</td>
<td>High Speed</td>
</tr>
</tbody>
</table>
When to Run Aeration Fans

Typical Aeration airflow rates < 1/50 cfm per bushel

- Will not appreciably change grain moisture content even in rainy weather
- Run fans continuously until aeration front has passed through the grain column
Crop drying fans have higher airflow rates

- Only operate when the air humidity is below 60% and the grain temperature is 10 to 15 degrees warmer than outside air temperature
- During warm periods, aerate during the cooler part of the day (evening or early morning)
Aeration Management

- Stop aeration as soon as cooling or warming is complete
- Cover the fan when not aerating
- If top crusting occurs, break up the crust and then turn on the aeration fan
S.L.A.M. Post Harvest Management Strategy

- Sanitation
- Loading
- Aeration
- Monitoring
Monitoring

- Acquire and use grain sampling equipment to detect insects, high moisture grain and hot grain pockets
Monitoring

- Inspect at least once a month during the winter.
- Inspect at least once every 2 weeks during the spring, summer and fall.
Monitoring

- Condensation on the grain surface, crusting, wet areas, molds and insects
- Non-uniform temperatures in the grain mass, and pockets or layers of high-moisture grain
- Sour or musty odors
Caught in the Grain

- Entrapments in Flowing Grain
- The Collapse of Bridged Grain
- Collapse of a Vertical Mass of Grain
Caught in the Grain

Safety Precautions:

• Keep children away from flowing grain

• Warn all workers of the potential dangers

• Install warning decals

• Shut off the power to unloading equipment before entering a bin

• Never enter a grain bin alone
Safety Precautions

- Review safety procedures with all workers, family and visitors
- Maintain shield and guards on all equipment
- Wear a respirator when entering a bin
- Install ladders inside bins
Take Home Message

- Drying soybeans is a challenge
- Keep drying temperatures between 85 – 130 °F
- Keep air relative humidity above 40%
- Store at the proper moisture content
- Follow S.L.A.M. post-harvest management strategy
- Play it safe around grain bins
Questions