A New Way Of Looking At Bunker Silage Density

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Why Care About Bunker Silage Density?

Density affects:

- How much you can get in your bunker
- How much loss during storage
- Profitability
Bunker Capacity:
180’ x 40’ x 12’
Bunker DM Losses As Affected By Density – 180 days storage

Based on Ruppel, 1992
**Benefits of Improved Bunker/Pile Silo Packing**

**Assume:**
- 50% Corn Silage
- 500 Cow Herd
- 5% Opportunity Cost
- Harvest Rate 80 T AF/Hr
- Layer Thickness 6”
- Feed Value = $0.042/lb DM
- Extra Storage Pad = $0.75/sq ft

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<thead>
<tr>
<th>Achieved Density (lbs DM/cu ft)</th>
<th>16</th>
<th>14</th>
<th>12</th>
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</thead>
<tbody>
<tr>
<td>Packing Tractor Weight (lbs)</td>
<td>50,000</td>
<td>36,000</td>
<td>25,000</td>
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<tr>
<td>Tractor Initial Cost ($)</td>
<td>163,000</td>
<td>149,000</td>
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<td>Init. Cost Additional Storage ($)</td>
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<td>Extra Storage Cost (20 yr)($/Yr)</td>
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<td>Feed Value Lost Cost ($/Yr)</td>
<td>14,061</td>
<td>15,924</td>
<td>17,788</td>
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<td>Tractor Annual Cost (10 yr)($/Yr)</td>
<td>5,324</td>
<td>3,622</td>
<td>2,905</td>
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<td>Total Annual Cost ($/Yr)</td>
<td>19,385</td>
<td>20,096</td>
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<td>Cost Reduction ($/Yr)</td>
<td>2,163</td>
<td>1,452</td>
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Holmes, 2007
The Old Target: Improving Dry Matter Density
WI Study of Silage Densities in Bunker Silos

- 19 extension agents collecting samples
- 87 hay crop silages
- 81 corn silages
- Surveyed the packing practices
Dry Matter Density in Bunkers Based on WI Survey

Affected by:

- Tractor weight
- Layer thickness
- Packing time
- Silage height
- DM content
How to Improve Silage Density

- Spreadsheet tools:
  - Bunker Silo Density Calculator
  - Silage Pile Density Calculator

- http://www.uwex.edu/ces/crops/uwforage/storage.htm
# Bunker Silo Density Calculator

## Spreadsheet to Calculate Average Silage Density in a Bunker Silo (English Units)

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<tbody>
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<td>Est. Average Wet Density (lbs AF/cu ft)</td>
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<td>Maximum Achievable Bulk Density (lbs AF/cu ft)</td>
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- Values in yellow cells are user changeable
- Typical values: 16-20 T/AF/hr

**Maximum Height**: 16 ft

**Wall Height**: 12 ft

- Recommended range of DM content = 0.3-0.4
- Recommended value is 0 inches or less

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- **Tractor Packing Time (% of Filling Time)**
  - Tractor # 1: 100%
  - Tractor # 2: 100%
  - Tractor # 3: 100%
  - Tractor # 4: 100%

- **Proportioned Total Tractor Weight (lbs)**
  - 80,000 lbs

- **Average Silage Height (feet)**
  - 14.0 ft

- **Packing Factor**
  - 441.0

- **Est. Average Wet Density (lbs AF/cu ft)**
  - 44.2 lbs

- **Maximum Achievable Bulk Density (lbs AF/cu ft)**
  - 73.3 lbs

- **Gas Filled Porosity**
  - 0.40

- **Est. Average Dry Matter Density (lbs DM/cu ft)**
  - 15.0 lbs

- **Maximum Achievable DM Density (lbs DM/cu ft)**
  - 26.7 lbs
So, What Is The Problem With Dry Matter Density?
Problem 1 With DM Density

- How do you estimate how you are doing during the packing process?
Problem 2 With DM Density

- Porosity – gas filled voids around the silage particles
- Losses increase proportionally as porosity increases
- What happens to porosity at fixed DM density when DM content changes?

![Chart showing porosity at different DM densities]
Porosity as a Function of DM Content and DM Density

![Graph showing porosity as a function of dry matter content and density.](image)
The New Target: Improving Bulk Density
Porosity as a Function of DM Content and Bulk Density

![Graph showing porosity as a function of dry matter content and bulk density.]
Benefits Of Bulk Density

- Porosity is relatively insensitive to the DM content of the crop
- Easier to estimate density on the fly while filling
  - Weight of forage put in the silo divided by the volume filled
Estimating Volume

Volume \approx \frac{1}{2} L \cdot W \cdot H
Estimating Volume

Volume \approx L_1 \cdot H \cdot W + \frac{1}{2} L_2 \cdot W \cdot H
Minimum Bulk Density Target

- 44 lbs./cu. ft.
- 700 kg/cu. m
How to Improve Silage Bulk Density

- Same spreadsheet tools as for DM density:
  - Silage Pile Density Calculator
  - Bunker Silo Density Calculator

- http://www.uwex.edu/ces/crops/uwforage/storage.htm
**Bunker Silo Density Calculator**

| A                        | B                                 | C       | D       | E       | F       | G       | H       | I       | J       | K       | L       | M       | N       | O       | P       | Q       | R       | S       |
|--------------------------|-----------------------------------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|---------|
| **Bunker Silo Wall Height (feet)** | 12                                 |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| **Bunker Silo Maximum Silage Height (feet)** | 16                                 |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| **Silage Delivery Rate to Bunker (T/AF/hr)** | 180                                |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| **Silage Dry Matter Content (decimal is 0.35)** | 0.35                               |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| **Silage Packing Layer Thickness (inches)** | 6                                  |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |

| Tractor #1               | Tractor weight (lbs) = 10,000       | 42,000  |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Tractor #2               | Tractor weight (lbs) = 10,000       | 42,000  |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Tractor #3               | Tractor weight (lbs) = 10,000       | 42,000  |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Tractor #4               | Tractor weight (lbs) = 10,000       | 42,000  |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| Proportioned Total Tractor Weight (lbs) | 88,000                             |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |
| **Average Silage Height (feet)** | 14.0                               |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |         |

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How Density Changes With DM Content For Identical Packing

Bottom line: The drier the crop, the more you have to do to get above the target bulk density.
Packing Operation

- Progressive wedge
- Thin layers (6 in.)
- Uniform coverage: two directions, multiple passes
- Continuous
- Drive slowly, avoiding wheel slip
Packing Vehicle

- Heavy tractor(s), weighted within specs
- Robust transmission with shuttle shift
- Blade or bucket
- Roll over protection with seat belts
- 4-Wheel drive or assist
- Wheels: well-lugged, high tire pressure
- Experienced operator(s)
Packing Operation

With multiple packing tractors, have a plan to work together, avoiding accidents
High bunker density is a profitable goal that minimizes losses, reduces storage costs.

New target of increasing bulk density:

Minimum bulk density of 44 lbs./cu. ft.

Still use a combination of heavy packing tractors, thin layers and packing time per ton to achieve high density.
Questions?

Presentation will be posted on the U.S. Dairy Forage Research Center web site

www.ars.usda.gov/mwa/madison/dfrc

Or “google” dairy forage research