Documentation
Bunker Silo Silage Density Calculator

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Purpose:

This spreadsheet was designed to inform producers and those advising producers about factors that are important for achieving high silage density when filling a bunker silo.

Computer Software Requirements:

The spreadsheet was designed to operate with Microsoft Excel-97. Set the screen size **%** in the upper toolbar so column **I** is visible on the screen.

Inputs:

User changeable values can be entered into spreadsheet cells with a yellow background color. Intermediate values calculated by the spreadsheet are printed in cells with a green color. The output cells have a pink color. Some advisory notes use a blue cell background color. Only yellow background cells should be changed by users. The other cells are protected from being changed by users.

The following variables must be entered by users:

1. Bunker silo wall height (cell F7) is the height of the bunker silo wall measured in feet from the bunker silo floor to the top of the wall. The assumption is that silage is filled to the top of the wall. Typical values are 6 to 16 ft. For a pile, wall height would be 0 ft.

2. Bunker silo maximum silage height (cell F9) is the maximum height of the silage measured in feet from the bunker silo floor to the top of the silage. This maximum height of silage is assumed to be midway between each wall.

3. Silage delivery rate to bunker (cell F11) is the average rate at which silage is pushed into the bunker silo by the filling tractor(s). The units are Tons of silage As Fed per hour (TAF/hr). Typical values for field harvest rate are given in Table 1. Actual delivery rate may be less than these values if transportation does not keep up with the harvester. The larger this number, the lower the estimated density.

TABLE 1. Typical Harvest Rates for Forage Harvesters

Crop	Harvest Rate (TAF/hr)*	
	Towed by 250 hp Tractor	Self-propelled 450 hp engine
Hay	60	110
Corn	100	180

* Personal communication with Dr. Kevin Shinners, Biological Systems Engineering Dept., UW Madison

4. Silage dry matter content (cell F13) is the average dry matter content of the forage entering the silo expressed in decimal form. Typical values are 0.3 to 0.4. The larger this number, the higher the estimated density. Dry matter content less than 0.3 can cause the Maximum Achievable Density (cell F30) to occur as the forage becomes saturated following good packing.

5. Silage packing layer thickness (cell F15) is the depth of forage (measured in inches) as deposited in the bunker silo before being packed by driving on the forage with the packing tractor(s). Values vary in the range of 2 to 36 inches. The recommended value is 6 inches or less. The smaller this number, the higher the estimated density.

6. Packing tractor weight (cells F19-F22) is the weight of each tractor (measured in lbs) used to pack the forage during filling. The weights of as many as four tractors can be entered. Typical values fall in the range of 10,000 to 60,000 lbs/tractor. The larger this number, the higher the estimated density.

7. Tractor packing time (cells H19-H22) is expressed as the ratio of time a tractor spends packing to the time it takes to fill the bunker silo. Typical values are between 0 and 100%. For example, if tractor #1 is used to push up forage and pack forage continuously between loads, its packing time is 100%. If tractor #2 is used to pack forage when there is an operator available, say half the time the bunker silo is being filled, the packing time for tractor #2 is 50%. A value greater than 100% is possible if a tractor packs beyond the filling time. The larger this number, the higher the estimated density.
   Error messages (cells I19-I22) will appear as red text on screen if an incorrect value is entered in either cell groups F19-F22 or H19-H22. When an error message appears, enter realistic values for cells in columns F and H.

Intermediate Output (green background):

1. Proportioned total tractor weight (cell F23) is the time weighted total weight of tractors used to pack the forage. This value is used in the Packing Factor (cell F26), which relates density to tractor weight. The larger this number, the higher the estimated density. More accurate estimates of dry matter density result when tractors of similar weight are used. (For example when a second tractor is much lighter (<40%) than the first, the second tractor will not improve density. We are uncertain of the prediction accuracy when this condition is used.)

2. Average silage height (cell F24) is the calculated average depth of forage across the entire width of the bunker silo. The larger this number, the larger the estimated density.

Output (pink background):

1. Packing factor (cell F26) is directly related to average packing tractor weight, silage dry matter content and sum of tractor packing time and inversely related to silage packing layer thickness and silage delivery rate to the bunker. Increasing the packing factor results in increased average dry matter density.

2. Estimated average dry matter density (cell F27) is measured in lbs of forage dry matter per cu ft of packed forage following the fermentation stage. The desired range of values is 14 to 28 lbs DM/cu ft. The larger the density, the lower the expected losses of forage due to aerobic deterioration during storage and feed out. If the estimated dry matter density is less than 14 lbs DM/cu ft, try increasing tractor weight, dry matter content into the range of 0.3 to 0.4, tractor packing time or number of tractors packing, or decreasing silage packing layer thickness. If the bunker silo has not yet been constructed, consider adding wall height as a method of increasing estimated dry matter density. See 3. below to be aware of the upper limit placed on this value.

3. Maximum achievable dry matter density (cell F30) is measured in lbs. of forage dry matter per cubic foot of packed forage following the fermentation stage. This is the density which could be achieved if the forage is packed to the point of moisture saturation. The forage can be packed no more densely than this value for a given moisture content of forage as it is placed into the silo. The "Estimated Average Dry Matter Density" (cell F27) is limited to this maximum value in the spreadsheet. When the "Estimated Average Dry Matter Density"(cell F27) is lower than the "Maximum Achievable Dry Matter Density", one can assume the average moisture content of the forage in the storage is less than saturation. However there still may be seepage or effluent coming from the silo at average densities approaching the maximum value because density at the bottom of the silo may have reached the maximum.

Changes Made Since the April 7, 2000 Version of the Spreadsheet

1. Maximum Achievable Dry Matter Density and its limitation on the Estimated Average Dry Matter Density were added.

2. Error limiting checks were added to the combination of Tractor Weight and Tractor Packing Time.

3. The Percent Packing Time influence on Proportioned Number of Packing Tractors was changed to 100% from the maximum value entered into that column.

4. The Packing Factor equation is now based on the maximum value achievable based on combination of packing tractor weight and packing time values entered.

5. Typical harvest rates (Table 1) were increased.

Changes Made Since the April 25, 2001 Version of the Spreadsheet

1. Proportioned Number of Packing Tractors was removed. This value was not used to make calculations in the spreadsheet and could contribute to confusion of the user.

2. Proportioned Average Tractor Weight was removed. This value was not used to make calculations in the spreadsheet and could contribute to confusion of the user.