

# DENSITY AND POROSITY IN BUNKER AND PILE SILOS

Brian Holmes, Extension Dairy Engineer Specialist, UW-Madison

## Why is silage density important when packing bunkers and piles?

Attaining a high silage density is important for two primary reasons. Most importantly, density and dry matter content determine the porosity of the silage. Porosity, in turn, sets the rate at which air moves into the silo and subsequently the amount of spoilage which occurs during storage and feedout. Kurt Ruppel measured dry matter loss for alfalfa silage and developed an equation to relate the loss to density. Table 1 summarizes those results. The higher the density, the greater is the capacity of the silo. Thus, higher densities generally reduce the annual cost of storage per ton of crop by both increasing the amount of crop entering the silo and reducing crop losses during storage.

**TABLE 1. Dry matter loss as influenced by silage density**

Dry Matter Density (lbs DM/ft <sup>3</sup> )	DM Loss, 180 days (%)
10	20.2
14	16.8
15	15.9
16	15.1
18	13.4
22	10.0

## So, what is porosity and why is it important?

Porosity is a measure of the voids between the solid particles of a material. Pore space can be filled with fluids including gas and/or water in silage. The “gas filled” porosity allows gases to move within the material. For gases to move throughout the material, the pores must be continuous. Closed pores do not contribute to gas flow. The preferred gas in stored silage is carbon dioxide. In high concentration, it displaces oxygen which contributes to aerobic microbial activity. Aerobic microbial

activity decomposes available carbohydrates with resultant dry matter loss. Evidence that aerobic activity is occurring is heating silage. Evidence that aerobic activity has occurred for some time is increased fiber and crude protein contents, higher ammonia, bound protein, elevated pH and in extreme cases moldy gray to black colored silage.

## If I am going to use porosity as a measure of how well I have packed my silage, how do I measure it?

Porosity is difficult to measure in the laboratory and probably impossible to measure in the field. An equation relates porosity to bulk density (as fed density) of organic materials, ash and dry matter content. This equation was used to develop Figure 1. From this graph, porosity is most influenced by bulk density over the range of dry matter contents recommended (0.30-0.40) for ensiling in bunkers, bags and piles. We have recommended a minimum dry matter density of 15 lbs DM/ft<sup>3</sup> as a reasonably attainable density and to avoid excessive dry matter loss. From Table 2 it is apparent the porosity varies quite widely (~20 - 60%) for the combinations of dry matter content and bulk density that produce a dry matter density of 15 lbs DM/ft<sup>3</sup> (note bold values for DM density meet or exceed 15 lbs DM/ft<sup>3</sup>). That being the case, it may be better to recommend a maximum porosity in the range of 30-40%. However, because porosity is relatively constant for a given bulk density over a typical range of ensiling DM contents and because bulk density is more readily measured than porosity, it may be better to recommend a minimum bulk density.

A minimum bulk density of 44 lbs AF/ft<sup>3</sup> keeps porosity below 40% within the recommended range of DM content. An

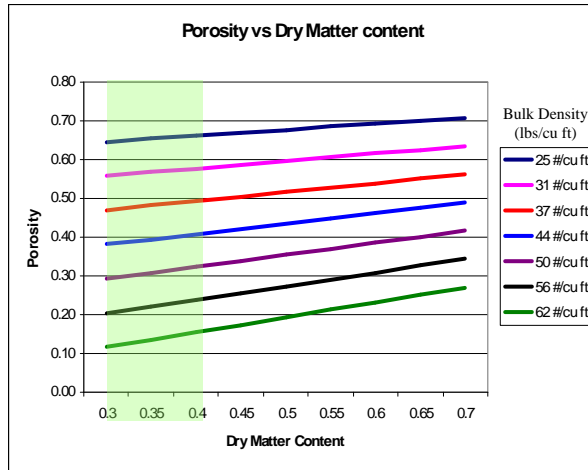
For more information,  
please contact:

Brian J. Holmes  
Extension Specialist  
UW- Madison  
(608) 262-0096  
[bjholmes@wisc.edu](mailto:bjholmes@wisc.edu)

Richard E. Muck  
Agricultural Engineer  
USDA-ARS Dairy Forage  
Research Center  
(608) 890-0067  
[remuck@wisc.edu](mailto:remuck@wisc.edu)



example may be useful here. If one wants to achieve a bulk density of 50 lbs AF/ft<sup>3</sup>, what dry matter density must be achieved? From Table 2, forage at 30% dry matter can be packed to 15 lbs DM/ft<sup>3</sup> to give the desired bulk density, but dryer material at say 40% dry matter must be packed to 20 lbs DM/ft<sup>3</sup> a much more difficult task. In both cases, the porosity is close to 30%.



**Figure 1. Graph of porosity (decimal) vs. dry matter content (decimal) for various bulk densities**

**How do I achieve a minimum recommended bulk density of 44 lbs/ft<sup>3</sup>?**

Density is primarily a function of the packing practices used in filling bunker or pile silos. The main factors are the number and weight of packing tractors, packing time, layer thickness, crop dry matter content and height of the bunker or pile. Resources for estimating silage densities based on your conditions and packing practices are the Bunker Silo Density Calculator and the Silage Pile Density Calculator. These are Excel spreadsheets available from the UW Team Forage Harvesting and Storage website (<http://www.uwex.edu/ces/crops/uwforage/storage.htm>).

**Table 2. Porosity and Dry Matter Density as a Function of Bulk Density and Dry Matter Content**

Bulk Density (lb AF/ft <sup>3</sup> )			30	35	40	45	50	55
Dry Matter (decimal)	Max. DM Density (lb DM/ft <sup>3</sup> )	Max. Bulk Density (lb AF/ft <sup>3</sup> )	Porosity(%) (DM Density, lb DM/ft <sup>3</sup> )					
0.25	17.0	68.1	55.9 (7.5)	48.6 (8.8)	41.3 (10.0)	33.9 (11.3)	26.6 (12.5)	19.2 (13.8)
0.30	20.8	69.3	56.7 (9.0)	49.5 (10.5)	42.3 (12.0)	35.1 (13.5)	27.9 (15.0)	20.7 (16.5)
0.35	24.7	70.6	57.5 (10.5)	50.5 (12.3)	43.4 (14.0)	36.3 (15.8)	29.2 (17.5)	22.2 (19.3)
0.40	28.8	72.0	58.3 (12.0)	51.4 (14.0)	44.5 (16.0)	37.5 (18.0)	30.6 (20.0)	23.6 (22.0)
0.45	30.0	73.4	59.1 (13.5)	52.3 (15.8)	45.5 (18.0)	38.7 (20.3)	31.9 (22.5)	25.1 (24.8)
0.50	37.4	74.9	59.9 (15.0)	53.3 (17.5)	46.6 (20.0)	39.9 (22.5)	33.3 (25.0)	26.6 (27.5)



An EEO/Affirmative Action employer, the University of Wisconsin provides equal opportunities in employment and programming, including Title IX and ADA requirements.