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SHRINK IS A DECEPTIVE TERM

Brian Holmes, Professor Emeritus, UW - Madison

The term shrink is used widely in the feed industry. It frequently is used to refer to the loss of feed during harvest, handling, and storage. Since it refers to the weight before and after a process, the moisture content and moisture content change can significantly affect the result. Care should be used when interpreting the results of a shrink calculation.

Definitions

Shrink Loss is the Weight of As Fed (AF) Feed lost divided by the Weight of Original AF Feed multiplied by 100% and is expressed as a percentage. In equation form it is expressed as:

Shrink Loss (%) = [(Weight Original Feed AF – Weight Final Feed AF) / Weight Original Feed AF] * 100%

Dry Matter Loss is the Weight of Feed Dry Matter (DM) lost divided by the Weight of Original Feed DM multiplied by 100% and is expressed as a percentage. In equation form it is expressed as:

Dry Matter Loss (%) = [(Weight Original Feed DM – Weight Final Feed DM) / Weight Original Feed DM] * 100%

When feed is removed from a quantity of feed, the dry matter and the moisture are lost in equal proportions. Examples of this include forage blowing out of a transport vehicle, vermin consuming feed from storage, feed lost during handling, etc. However, there are situations where dry matter loss and moisture loss (gain) occur at different rates. For example, weight in the form of moisture is added to feed when precipitation falls on the feed. At that instant, there is no dry matter loss, but a negative shrink occurs. In the case where microbial and/or plant respiration is occurring, dry matter is being lost in the form of carbon dioxide release and moisture is produced. When the moisture cannot escape from the mass, shrink is not in direct proportion to the weight of dry matter lost. There are cases where weight is removed in the form of moisture being removed at a much higher rate than dry matter being lost. Examples of this include feed drying and leachate leaving the feed. A negative shrink and a negative dry matter loss can occur when dry matter is added to the feed as in soil or stones during harvest or scooping feed from the ground.

Consider the situation where 1% of the forage is blown out of a truck while traveling from the field to storage. Some assumptions used in the analysis are:

- Truck Box = 10’ * 6’ * 30’ = 1,800 ft^3
- Dry Matter Density = 5 lbs DM/ft^3
- Moisture Content = 65%

Load on Truck = 1,800 ft^3 * 5 lbs DM/ft^3 = 9,000 lbs DM
Load on Truck = 9,000 lbs DM/(1.00 - 0.65) = 25,714 lbs AF
1% Shrink Loss = 0.01 * 25,714 lbs AF = 257 lbs AF
DM Loss = 257 lbs AF * 0.35 = 90 lbs DM
DM Loss = (90 lbs DM / 9,000 lbs DM) * 100% = 1%

In this case, DM Loss is the same as Shrink Loss.

However, consider the case where 1% of the weight on the truck is lost by water evaporating from the top surface and no material blows from the truck. In this case the only loss is that of water.

Water Loss = 1% Shrink Loss = 0.01 * 25,714 lbs AF = 257 lbs H_2O
Water in the original load = 25,714 lbs AF - 9,000 lbs DM = 16,714 lbs H_2O
Water after loss = 16,714 lbs H_2O – 257 lbs H_2O = 16,457 lbs H_2O

Average Moisture content of load after drying = [16,457 lbs H_2O/ (25,714 lbs AF - 257 lbs H_2O)] * 100% = 64.64% (original moisture was 65%).

In this case, the dry matter loss is 0% but the shrink loss is 1%.

Consider the example where forage is harvested at 73% moisture and placed into a silo. Leachate can occur while the moisture content is above 70%. Other assumptions for the analysis:

Bunker silo volume = 30’ * 150’ * 12’ = 54,000 ft^3
Silage bulk density in storage = 45 lbs AF/ft^3
Leachate solids content = 5%

Forage placed into storage = 54,000 ft^3 * 45 lbs AF/ft^3 = 2,430,000 lbs AF= 1,215 T AF
Dry Matter in original forage = 2,430,000 lbs AF * 0.27 = 656,100 lbs DM
By trial and error, weight AF in storage when leachate has drained out and final moisture content is 70% is 2,140,000 lbs
Leachate removed to achieve 70% moisture = 290,000 lbs leachate
Water in leachate = 275,500 lbs. water (290,000 lbs * 0.95)
Dry Matter in leachate = 14,500 lbs DM (290,000 lbs * 0.05)

Shrink Loss from leachate= (290,000 lbs. / 2,430,000 AF) * 100% = 11.9%
Leachate DM Loss = [14,500 lbs DM/ 656,100 lbs DM] * 100% = 2.2%

Thus, when leachate losses occur, shrink loss is much higher than dry matter loss.

In most silos, however, most dry matter losses occur because of microbial respiration. Let's add to the previous example a 10% respiration loss of the remaining dry matter and assume that 60% of the DM weight loss remains as water after respiration (see explanation below).

Remaining DM after leachate = 2,140,000 lbs AF * 0.3 = 641,600 lbs DM
DM lost from respiration = 641,600 lb DM * 0.10 = 64,160 lbs DM
DM loss from respiration = (64,160 lbs / 656,100 lbs) * 100% = 9.8%
AF Weight lost from respiration = 64,160 * (1.00 – 0.60) = 25,664 lbs AF
Shrink loss from respiration = (25,664 lbs / 2,430,000 lbs) * 100% = 1.1%

Thus, for respiration losses, DM loss is much greater than shrink loss.

Combining leachate and respiration losses:

Total Shrink loss = leachate + respiration = 11.9% + 1.1% = 13.0%
Total DM loss = leachate + respiration = 2.2% + 9.8% = 12%

In this example the total shrink and DM losses were similar. However, most of the shrink was due to leachate, whereas respiration was the cause of most of the DM loss.

Explaining 60% Weight Retention with Dry Matter Loss from Respiration/Spoilage

When sugar in forage breaks down in the presence of oxygen during respiration, the resulting products are carbon dioxide, water, and heat following the equation:

$C_6 H_{12} O_6 + 6O_2 \rightarrow 6CO_2 + 6H_2 O + \text{heat}$

$180 + 192 \rightarrow 264 + 108$

(The numbers below the equation are molecular weights.)

The ratio of water molecular weight to the original sugar molecular weight is:

(108/180)*100% = 60%

Thus, as sugar dry matter is respired, 40% of its weight is released in the form of carbon dioxide while 60% of the weight remains as water. Table 1 was developed to quantify the shrink of silage with different dry matter losses assuming an initial moisture content of 65% and 60% of the original weight remaining as moisture following dry matter destruction. Note how the moisture content increases, thus, masking the actual amount of shrink. Shrink is a deceptive term because it encompasses changes in moisture content. Unless a person understands and includes the changes in moisture content, the use of shrink can be misleading. Also, because shrink is based on an as-fed basis, the numerical value of shrink is low, as can be seen in table 1. One might not think much has been lost when the value of shrink is 2.8%, but in reality 20% of the dry matter (a large number) has been lost when this occurs in forage which was initially 65% moisture.

Table 1. Shrink vs Dry Matter Loss Due To Respiration with Initial Moisture of 65%.

Dry Matter Loss (%)	Shrink (%)	Moisture Content at Removal (%)
1	0.14	65.3
5	0.70	66.5
10	1.40	68.1
15	2.10	69.6
20	2.80	71.2

Conclusion

An example was shown where shrink and dry matter loss are the same. We have seen an example where shrink occurs due to moisture loss but dry matter loss is zero. The more common situation of concern is when dry matter loss occurs due to aerobic respiration and the moisture remains in the silage. In this case, the shrink is relatively low whereas a higher dry matter loss occurs.