Calculating Grain Weight Shrinkage in Corn Due to Mechanical Drying

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Following harvest, a corn grower must usually decide whether to sell wet corn "as is" at a moisture-discounted market price or mechanically dry the grain (on-farm or by custom drying) at a total cost the grower hopes is less than the moisture discount. One of the expenses involved in mechanically drying grain is the "cost" of the weight loss that occurs during the drying process. This weight loss by drying is referred to as "shrink" and is expressed as a percentage of the original shrinkage in order to accurately determine the total cost of mechanical drying. (For more information on determining the profitability of on-farm drying, see NCH 21 "Economics of On-Farm Corn Drying.")

Grain buyers use a number of different procedures to calculate how much grain they will actually have after the grain they buy is dried. The calculation process is called "pencil shrink." Although pencil shrink is a somewhat complicated process, corn growers can maximize the net sale by understanding pencil shrink and evaluating the sale alternatives by obtaining more than one price quote when selling their grain.

There is no standard method for pencil shrink. This publication describes several popular pencil shrink methods, provides examples of their calculations, and discusses the use of shrinkage as a basis for evaluating custom drying and grain sale alternatives.

Calculating the Components of Shrink

Water Shrink

By far, the major portion of weight loss by drying is the weight of the water that is removed. A good way to understand the basic concept of shrink is to consider the ideal situation where all of the weight loss is

water. Total water shrink is calculated by dividing the weight of water lost during drying by the total initial grain weight. The result is then multiplied by 100 and expressed as a percentage.

Our first example involves 1,000 lb. of corn at 25% moisture. If the grain is 25% water, it will contain 250 lb. of water and 750 lb. of dry matter. How much shrinkage occurs, due to water loss alone, if the 1,000 lb. of grain is dried to 15.5% moisture? We can calculate it.

The dried corn still contains 750 lb. of dry matter, but now the dry matter is 84.5% (100% minus 15.5%) of the total weight. Therefore, the total weight of the dried grain is 750 lb. divided by 0.845, or 887.57 lb.

After drying, the grain contains 137.57 lb. of water (887.57 lb. minus 750 lb.). Therefore, 112.43 lb. of water was removed during drying (250 lb. minus 137.57 lb.) Now that the weight of water lost has been calculated, the total water shrink percentage in our example can be calculated by dividing 112.43 (lb. of water removed) by 1,000 (total initial grain weight) and multiplying the result by 100. The total water shrink is 11.24%.

> Total Water Shrink = (lb. water removed divided by
> original weight) times 100)
> = (112.43/1,000) x 100 = 11.24%

The grain was dried from 25% to 15.5%—a moisture reduction of 9.5 percentage points with an 11.24% loss of the original weight. The "water shrink factor" is calculated by dividing the percentage weight loss by the percentage moisture reduction. In this case, 11.24% divided by 9.5% gives a water shrink factor of 1.18% weight loss for each point of moisture removed.

The water shrink factor is a constant for a final moisture content. As in above, the water shrink is

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1.18% for each point of moisture removed when the final moisture content is 15.5%. However, the water shrink factor will change as the desired final moisture content changes. Table 1 gives the water shrink factors for a number of final moisture contents. For other final moisture contents, the water shrink factor may be calculated by the formula:

Water Shrink Factor	= 100 divided by (100 minus percent final moisture)

Table 1. Water shrink factors for drying shelled corn to various moisture levels.

Final moisture content (%)	Water shrink factor (% shrink per point)
15.5	1.183
15	1.176
14	1.163
13	1.149
12	1.136
11	1.126
10	1.111
9	1.099
8	1.087
0	1.000

Now, let's use the water shrink factor to calculate the amount of water shrink when corn is dried from 25% to 12% moisture, a removal of 13 percentage points of water. The formula for calculating total water shrink using the water shrink factor is:

Total Water Shrink	= (percentage points removed) times (water shrink factor)

The water shrink factor for 12% final moisture is 1.136% (100 divided by 88). Multiplying 13 by 1.136 equals 14.77% loss in weight due to the water removed during drying of 25% moisture corn to 12% moisture.

Handling Loss

Remember that, although most of the weight loss during drying is water, a small portion is dry matter. This loss is often called ("invisible shrink," but we prefer to call it "handling loss." Some of the handling loss is due to loss of volatile compounds such as oils, mechanical losses from broken kernels and foreign material, and possibly also due to respiration of the seed itself. Handling loss will normally be far less than that due to water.

The actual amount of handling loss will depend on the initial physical quality of the corn, the method of drying, and the handling processes during drying. Research at Iowa State University determined that on-farm handling losses ranged from 0.22 to 1.71%. Losses from commercial drying systems ranged from 0.64 to 1.33%. The 3-year on-farm average was 0.82% compared to 0.88% for the commercial facilities.

Methods of Calculating Total Shrink

Shrink factors used by grain buyers account for both water shrink and handling loss. Grain buyers typically use drying tables or a constant shrink factor to pencil shrink the grain they buy.

Method 1: Drying Tables

Grain drying tables include water shrink and a constant handling loss, usually 0.5% of the initial weight of the grain (see Table 4 in NCH 21). Using this method, the formula for calculating total shrink is:

Total Shrink	= (total water shrink) plus (handling loss)

If we were to dry shelled corn from 25% to 15.5% moisture (a removal of 9.5 percentage points), the total water shrink would be 9.5 multiplied by 1.183 (from Table 1), or 11.24% of the original grain weight. Add to this the 0.5% handling loss for a total shrink of 11.74%. Thus, if 1,000 lb. of 25% moisture corn were dried to 15.5% moisture, the total weight loss due to water and dry matter removal would be 117.4 lb. (1,000 multiplied by 0.1174). The resulting weight of the dried grain would equal 882.6 lb. (1,000 minus 117.4) using this shrink method.

Method 2: Constant Shrink Factor

Another pencil shrink method uses a constant shrink factor that is multiplied by each percentage point of moisture removed. Typical constant shrink factors range from 1.2 to 1.5% per point. Using this method, the formula for calculating total shrink is:

Total Shrink	= (constant shrink factor) times (points of moisture removed)

Total shrink calculated by this method contains the same value for water shrink as Method 1. The assumed handling loss in Method 2, however, will vary depending on the value of the constant shrink factor and initial moisture content of the grain.

For example, using a constant shrink factor of 1.3% per point of moisture removed, the total shrink for drying 1,000 lb. of 25% moisture corn to 15.5% moisture would equal 12.35% (9.5 percentage points multiplied by 1.3), compared to 11.74% calculated by Method 1. The water shrink remains the same and would be 11.24%, as shown in the previous example. The handling loss would be 1.11% (total shrink of 12.35% minus water shrink of 11.24%), which is greater than the 0.5% used in Method 1.

As the constant shrink factor is increased, the assumed handling loss increases. Table 2 provides handling loss values for various constant shrink factors based on 15.5% final corn grain moisture. The handling loss is calculated by subtracting the water shrink from the total shrink. Some of these values are much less and others are much greater than the actual handling losses measured in research.

The average handling losses were less than 1.0% in the Iowa State research. Sellers can use Table 2 to determine if the shrink factor the buyer is using assesses a "reasonable" handling loss (1.0% or less). For example, if the seller has 28% corn, a shrink factor of 1.25 includes a handling loss of 0.83%,

Table 2. Handling for various shrink factors based on 15.5% final corn moisture.

Initial moisture content	Shrink factor (% per point)						
	1.20	1.25	1.30	1.35	1.40	1.45	1.50
(%)	----------------------------------Handling loss (%)----------------------------------						
32	0.27	1.10	1.92	2.75	3.57	4.40	5.22
30	0.24	0.97	1.69	2.42	3.14	3.87	4.59
28	0.21	0.83	1.46	2.08	2.71	3.33	3.96
26	0.17	0.70	1.22	1.75	2.27	2.80	3.32
24	0.14	0.57	0.99	1.42	1.84	2.27	2.69
22	0.11	0.43	0.76	1.08	1.41	1.73	2.06
20	0.07	0.30	0.52	0.75	0.97	1.20	1.42
18	0.04	0.17	0.29	0.42	0.54	0.67	0.79

Table 3. Initial corn weights required to give 56 pounds of dry shelled corn after shrinking wet shelled corn to 15.5% moisture for various initial moisture levels and shrink factors.

Initial moisture of grain	Shrink factor (% per point)							
	1.18	1.20	1.25	1.30	1.35	1.40	1.45	1.50
(%)	---------------------------------------lb. of wet corn---------------------------------------							
32	69.59	69.83	70.55	71.29	72.05	72.82	73.61	74.42
30	67.60	67.80	68.40	69.01	69.63	70.26	70.91	71.57
28	65.72	65.88	66.37	66.87	67.37	67.88	68.40	68.92
26	63.95	64.07	64.46	64.85	65.25	65.65	66.06	66.47
24	62.26	62.36	62.66	62.96	63.26	63.56	63.87	64.18
22	60.67	60.74	60.95	61.17	61.39	61.61	61.83	62.05
20	59.15	59.20	59.34	59.48	59.62	59.77	59.91	60.05
18	57.71	57.73	57.81	57.88	57.96	58.03	58.11	58.18
16	56.33	56.34	56.35	56.37	56.38	56.39	56.41	56.42
15.5	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00

which is reasonable from the seller's point of view. However, a shrink factor of 1.3% assesses a 1.46% handling loss, which is substantially greater than a normal expected handling loss.

Evaluating Custom Drying Alternatives

When custom drying, growers should seek more than one estimate of cost of drying and choose the one that returns the greatest number of bushels. The number of bushels after drying can be determined by using Tables 3, 4, or 5 if the final moisture content is 15.5, 14, or 13%, respectively. If another final moisture content is used, the number of dry bushels can be determined with the following formula.

No. of dry bu.	= [(100 minus total shrink) divided by 100)] times (No. of wet bu.)

For example, consider again 1,000 lb. of corn at 26% moisture and two drying quotes. The first quote includes shrinking to 15.5% moisture using a shrink factor of 1.4% per point. The total shrink is 14.7% (10.5 points removed times 1.4%). The number of wet bushels is 17.86 (1,000 lb. divided by 56 lb./bu.). Using the formula above, the number of dry bushels remaining is 15.23. Dividing the original weight by the wet bushel equivalent from Table 3 gives the same result (1,000 divided by 65.65). The total shrinkage loss in this example is 2.63 bu. (17.86 minus 15.23).

The second quote includes shrinking the grain to 13% moisture but only uses a shrink factor of 1.2% per point. The total shrink is 15.6% (13 points removed times 1.2%). The number of wet bushels is the same as above, 17.86. The number of dry bushels remaining would be 15.07, a shrinkage loss of 2.79 bu. Thus, even though the second quote involved a smaller shrink factor, the lower final moisture content resulted in a greater shrinkage loss than the first quote.

Evaluating Grain Sale Alternative

When selling wet corn, sellers should evaluate their sale alternatives by comparing not only per bushel price quoted, but also shrink factors and final moisture contents if the grain buyer is pencil shrinking the purchase. It is important for the seller to determine the assumed handling losses that each buyer is using for pencil shrinking the grain. If the handling loss is greater than 1%, then the loss is greater than the average loss reported from on-farm and commercial surveys.

For example, consider that a grower has 100,000 lb. of 20% corn for sale. Buyer #1 quotes a price of $2.50 per dry bu., uses a constant shrink factor of 1.25, and shrinks grain to a final moisture content of 14%. From Table 4, the wet bushel equivalent is found to be 60.54 bu. Dividing the 100,000 lb. by 60.54

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Table 4. Initial corn weights required to give 56 pounds of dry shelled corn after shrinking wet shelled corn to 14% moisture for various initial moisture levels and shrink factors.

Initial moisture of grain	Shrink factor (% per point)							
	1.16	1.20	1.25	1.30	1.35	1.40	1.45	1.50
(%)	--lb. of wet corn--------------------------------------							
32	70.82	71.43	72.26	73.11	73.98	74.87	75.78	76.71
30	68.80	69.31	70.00	70.71	71.43	72.16	72.92	72.68
28	66.89	67.31	67.88	68.46	69.05	69.65	70.26	70.89
26	65.08	65.42	65.88	66.35	66.83	67.31	67.80	69.29
24	63.37	63.64	64.00	64.37	64.74	65.12	65.50	65.88
22	61.74	61.95	62.22	62.50	62.78	63.06	63.35	63.64
20	60.20	60.34	60.54	60.74	60.94	61.14	61.34	61.54
18	58.73	58.82	58.95	59.07	59.20	59.32	59.45	59.57
16	57.33	57.38	57.44	57.49	57.55	57.61	57.67	57.73
14	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00

Table 5. Initial corn weights required to give 56 pounds of dry shelled corn after shrinking wet shelled corn to 13% moisture for various initial moisture levels and shrink factors.

Initial moisture of grain	Shrink factor (% per point)							
	1.15	1.20	1.25	1.30	1.35	1.40	1.45	1.50
(%)	--lb. of wet corn--------------------------------------							
32	71.65	72.54	73.44	74.37	75.32	76.29	77.29	78.32
30	69.60	70.35	71.11	71.89	72.68	73.49	74.32	75.17
28	67.67	68.29	68.92	69.57	70.22	70.89	71.57	72.26
26	65.84	66.35	66.87	67.39	67.92	68.46	69.01	69.57
24	64.11	64.52	64.93	65.34	65.77	66.19	66.63	67.07
22	62.46	62.78	63.10	63.42	63.75	64.07	64.40	64.74
20	60.90	61.14	61.37	61.61	61.84	62.08	62.33	62.57
18	59.41	59.57	59.73	59.89	60.05	60.22	60.38	60.54
16	58.00	58.09	58.18	58.27	58.36	58.46	58.55	58.64
14	56.65	56.68	56.71	56.74	56.77	56.80	56.82	56.85
13	56.00	56.00	56.00	56.00	56.00	56.00	56.00	56.00

gives 1651.8 dry bushels of corn. Multiplying the 1651.8 bu. by the quoted price of $2.50 per bu. results in a net sale of $4,129.50.

Buyer #2 quotes a price of $2.55 per dry bu., uses a table with 0.5% constant handling loss, and shrinks grain to 13% moisture. Water shrink per point moisture loss is 1.149 (from Table 1). Total water shrink would therefore be 8.04% (7 points removed times 1.149). Total shrink would be 8.54% (8.04% plus 0.5% handling loss). The original 100,000 lb. of wet corn is equal to 1,785.7 bu. The number of dry bushels remaining would equal 1,633.2 (using formula above). Multiplying the 1633.2 bu. by the quoted price of $2.55 per bu. results in a net sale of $4,164.66.

The quote from buyer #2 is the better sale alternative, assuming the cost for delivering grain is equal.

SUMMARY

Grain weight shrinkage due to mechanical drying includes weight loss due to removal of both water and dry matter. Water shrink is by far the major component of total shrinkage and the easiest to calculate. Calculated dry matter losses tend to be variable due to different pencil shrink procedures used within the grain industry. In order to accurately compare custom drying quotes or grain sale alternatives, the corn grower should determine the shrinkage costs associated with each and choose the alternative that either returns the greatest number of dry bushels or greatest net sale.