Understanding Grain Shrinkage and Expansion

Sammy Sadaka
Assistant Professor - Extension Engineer

Griffiths G. Atungulu
Assistant Professor

Gbenga Olatunde
Post Doctoral Associate

Introduction

Grain contains water and dry matter. The dry matter holds primary value to producers. Each type of grain has a base moisture content (MC) used for its pricing by the industry (Table 1). When any grain is delivered to an elevator above its base MC, buyers apply a "shrink factor" to adjust the quantity for the excess moisture. Farmers who deliver grain that is below the base MC give away grain weight that they could sell at the price of grain if the grain was at the base MC. This fact sheet will explore how much grain weight could be given away if grain was delivered above or below the base MC. It will also provide simple solutions to avoid losing some profit.

Table 1. Base moisture content and the corresponding number of pounds per bushel for common grains.

Grain	Base Moisture Content (%)	Pound/ bushel (lb/bu)
Corn	15.5	56.0
Soybean	13.0	60.0
Rice	13.0	45.0
Wheat	13.5	60.0
Grain sorghum	14.0	55.0

Note: Shrinkage and expansion calculated in this fact sheet adjust only for water loss or gain unless mentioned otherwise. Elevator shrink factors usually include an additional allowance for handling losses encountered when drying grain, which will be described later.

Grain Moisture Content

The MC of grain denotes the quantity of water per unit weight of grain. Grain MC is very important to the grain industry because it influences the grain market value. The grain price changes depending on its MC. Additionally, MC can influence the grain harvesting date. Harvesting grain below the optimum harvesting MC increases grain damage. Similarly, harvesting grain above the base moisture content (immature grains) will cause some grain damage. Immature kernels (high MC kernels) affect grain milling quality. In addition, storing grain above its base MC increases mold activity and thus decreases potential storage time.

MC could be expressed in two ways: wet basis (wb) or dry basis (db). Wet basis MC is often referred to as the "as is" basis. The grain industry (producers, handlers and processors) use wet basis MC exclusively, which is calculated as follows:

MC (%) = weight of water (lb) / weight of undried grain (lb) × 100%

Suppose you have 100 pounds of grain that is heated until all the water evaporates. After fully drying it, the remaining weight is 88 pounds. Therefore, the weight of the evaporated water is 12 lb (100 lb – 88 lb = 12 lb) assuming that all weight loss is due to water evaporation only. The grain MC is calculated as follows:

MC (%) = 12 (lb) / 100 (lb) x 100% = 12%

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It is known that grains are actively exchanging water with the atmosphere causing grain MC to either increase or decrease. In the following sections, we will explore grain shrinkage and expansion.

Grain Shrinkage and Expansion

When any grain is delivered to the elevator above its base MC, buyers apply a factor called "shrink factor" to adjust the quantity for the excess moisture. This is because grain buyers will not pay for the cost of removing excess water. Applying the shrink factor approximates the equivalent number of bushels that would be in the load if the grain were dried to the base MC. Conversely, some farmers often deliver grain to the elevator at moisture levels below the base MC. For example, on good drying days soybeans can come out of the field at 12%, 10% or even 8% MC (wet basis). This case demonstrates less profit to producers since the buyer will not apply an expansion factor.

Why Grain Shrinkage and Expansion Are Important

Simply, for economic reasons, many farmers want to make sure that their grain is dried close to the base MC before delivery to the elevator so they can gain premiums and avoid being charged for the grain shrink factor. Unfortunately, getting the grain to the exact base MC mentioned previously can be tricky. The financial penalty for delivering grain that is below the base MC could be higher than the financial penalty of the shrinkage discount. Growers who deliver grain below the base MC lose money because they could get more returns if the grain was at the base MC.

How Industry Determines the Grain Shrinkage Value

When farmers deliver a certain weight of their grain to the elevator at a certain MC, the number of wet bushels of this grain could be expressed as follows:

The number of wet bushels (bu) = wet weight (lb) / number of pounds per bushel (lb/bu)

Table 2 shows the grain shrinkage values for various grains at different MC levels.

The moisture shrink factor is varied based on the base MC of the grain. The moisture shrink factor for each single moisture-point can be calculated as:

The moisture shrink factor (–) = 100 / (100 – base moisture content %)

The elevator determines the moisture shrink for specific grain from the following equation:

The moisture shrink (%) = moisture shrink factor × (initial moisture content % – base moisture content %)

At this point, the elevator could determine the standard weight of this grain as follows:

The standard weight (bu) = number of wet bushels (bu) × (100 – % moisture shrink) / 100

It should be mentioned that the shrinkage calculated above was adjusted only for water loss. Elevators usually apply an additional allowance for handling losses encountered when drying grain.

Handling loss = 0.5%

Determination of the Total Shrink

The total shrink (%) = moisture shrink + handling loss

At this point, the elevator could determine the final weight of this grain, taking into consideration both the moisture loss and the handling loss, as follows:

The final weight (bu) = wet weight (bu) × (100 – total shrink) / 100

The following examples may provide some clarification of the methods and techniques used to calculate the shrinkage and expansion factors:

Grain Delivered at the Base Moisture Content

Suppose a farmer harvested and delivered 300,000 pounds of soybeans at 13% MC. The amount of water in these soybeans is 39,000 pounds (300,000 lb × 0.13 = 39,000 lb) in addition to 261,000 pounds of dry matter (300,000 lb – 39,000 lb = 261,000 lb). At 60 pounds per bushel of soybeans, this farmer has 5,000 bushels (300,000 lb / 60 lb/bu = 5,000 bu). Assume that this farmer sells the beans at $12 per bushel; it would generate $60,000 gross revenue.

Grain Delivered Above or Below the Base Moisture Content

Assume that this farmer harvested soybeans earlier while the MC was 16%. This farmer would still harvest 261,000 pounds of dry matter. It should be mentioned that dry matter would stay the same. As a result of harvesting soybeans at 16% MC, the total weight would be 310,714 pounds [261,000 lb / (1.00 – 0.16) = 310,714 lb]. The number of received bushels equals 5,178.6 "wet" bushels (310,714 lb / 60 lb/bu = 5,178.6 bu). These soybeans would contain 49,714 pounds of water (310,714 lb – 261,000 lb = 49,714 lb). The elevator does not pay for excess water in the price of soybeans. The elevator applies a shrink factor to adjust the quantity of grain they are buying according to the baseline MC. It is assumed that beans lose 1.149% [100 / (100.0 – 13.0) = 1.149] of their weight for each point of moisture removed going to a final moisture of 13%. However, the buyer may use a bit higher shrink factor than the 1.149% to account for handling losses during drying. Suppose the buyer uses a 1.3% total shrink factor and the elevator "pencil" shrinks the beans by 202.0 bushels (5,178.6 bu × 1.3 / 100 × 3 = 202.0 bu). This farmer is paid for 4,976.6 bushels (5,178.6 – 202.0). At $12 per lb of beans, the farmer's check would be $59,719 ($12 per bu × 4,976.6 bu = $ 59,719), which is $281 less than if this farmer had delivered the soybeans at 13% MC.

Alternatively, suppose the farmer harvests soybeans late at 10% MC. The beans would still have the same 261,000 pounds of dry matter. This farmer would harvest 290,000 pounds of wet soybeans [261,000 / (1.00 – 0.10) = 290,000 lb]. Soybeans contain only 29,000 pounds of water (290,000 lb x 10.0 / 100 = 29,000 lb). The number of received bushels equals 4,833.3 "wet" bushels (290,000 lb / 60 lb/bu = 4,833.3 bu). The buyer would pay for 4,833.3 bushels. That is 166.7 bu (5,000 bu – 4,833.3 bu = 166.7 bu) less than if the farmer delivered his beans at 13% moisture. The buyer would pay $57,999.6 (4,833.3 bu x $12 per bu) at $12 beans, a sizable $2,000.40 smaller than if he had delivered at 13% MC.

Table 2. Grain shrinkage table.

Moisture Content	Shelled Corn	Wheat	Soybean	Barley	Oats	Rye	Rice	Sun-flower	Grain Sorghum
%	lb/bu	lb/bu	lb/bu	lb/bu	lb/bu	lb/bu	lb/bu	lb/cwt base	lb/cwt base
5.0	49.81	54.63	54.95	43.20	28.97	50.69	41.21	94.74	90.53
6.0	50.34	55.21	55.53	43.66	29.28	51.23	41.65	95.74	91.49
7.0	50.88	55.81	56.13	44.13	29.59	51.78	42.10	96.77	92.47
8.0	51.43	56.41	56.74	44.61	29.91	52.35	42.55	97.83	93.48
9.0	52.00	57.03	57.36	45.10	30.24	52.92	43.02	98.90	94.51
10.0	52.58	57.67	58.00	45.60	30.58	53.51	43.50	**100.00**	95.56
11.0	53.17	58.31	58.65	46.11	30.92	54.11	43.99	101.12	96.63
11.5	53.47	58.64	58.98	46.37	31.10	54.42	44.24	101.69	97.18
12.0	53.77	58.98	59.32	46.64	31.27	54.73	44.49	102.27	97.73
12.5	54.08	59.31	59.66	46.90	31.45	55.04	44.74	102.86	98.29
13.0	54.39	59.66	**60.00**	47.17	31.63	55.36	**45.00**	103.45	98.85
13.5	54.71	**60.00**	60.35	47.45	31.82	55.68	45.26	104.05	99.42
14.0	55.02	60.35	60.70	47.72	**32.00**	**56.00**	45.52	104.65	**100.00**
14.5	55.35	60.70	61.05	**48.00**	32.19	56.33	45.79	105.26	100.58
15.0	55.67	61.06	61.41	48.28	32.38	56.66	46.06	105.88	101.18
15.5	**56.00**	61.42	61.78	48.57	32.57	56.99	46.33	106.51	101.78
16.0	56.33	61.79	62.14	48.86	32.76	57.33	46.61	107.14	102.38
17.0	57.01	62.53	62.89	49.45	33.16	58.02	47.17	108.43	103.61
18.0	57.71	63.29	63.66	50.05	33.56	58.73	47.74	109.76	104.88
19.0	58.42	64.07	64.44	50.67	33.98	59.46	48.33	111.11	106.17
20.0	59.15	64.88	65.25	51.30	34.40	60.20	48.94	112.50	107.50
21.0	59.90	65.70	66.08	51.95	34.84	60.96	49.56	113.92	108.86
22.0	60.67	66.54	66.92	52.62	35.28	61.74	50.19	115.38	110.26
23.0	61.45	67.40	67.79	53.30	35.74	62.55	50.84	116.88	111.69
24.0	62.26	68.29	68.68	54.00	36.21	63.37	51.51	118.42	113.16
25.0	63.09	69.20	69.60	54.72	36.69	64.21	52.20	120.00	114.67
26.0	63.95	70.14	70.54	55.46	37.19	65.08	52.91	121.62	116.22
27.0	64.82	71.10	71.51	56.22	37.70	65.97	53.63	123.29	117.81
28.0	65.72	72.08	72.50	57.00	38.22	66.89	54.38	125.00	119.44
29.0	66.65	73.10	73.52	57.80	38.76	67.83	55.14	126.76	121.13
30.0	67.60	74.14	74.57	58.63	39.31	68.80	55.93	128.57	122.86

Farmers always see how many bushels they lose when buyers pencil shrink grain that is above base MC level. When farmers deliver grain below the base MC, the loss is invisible. This is because most farmers do not calculate how many bushels they would have if their grain were at the base MC used for pricing.

Potential Solution for Farmers and Grain Buyers

Grains are hygroscopic, which means they can lose (reduce weight and volume) or gain moisture (increase weight and volume) depending on the dryness or wetness of the ambient air. It is advisable, if possible, to monitor the grain MC for timely harvesting. A calibrated hand-held moisture meter can be used for this purpose by randomly gathering grains across the field for MC measurement. Combines that are equipped with an MC monitor can be very useful to determine timely harvesting. Farmers should avoid harvesting grains at MC lower than the base MC.

Farmers who harvest grain at low MC are thinking of ways to increase grain moisture to the base moisture level. That might be done by aerating on high humidity days. Caution should be taken in aerating grains because rapid moisture addition can cause grain fissuring that usually results in grain breakage during milling. Consequently, it reduces the quality of milled rice for example. It should be noted that the U.S. Food and Drug Administration prohibits adding water to grain for increasing value.

Grain Blending

Blending is mixing grain of various qualities together to obtain a desired average product. MC is the most common, although by no means the only, blended characteristic. Many grain buyers currently gain income by blending grains containing different MCs to obtain a final product at the base MC. It is a profitable operation for the grain trader because one or more of the lots being blended could have been purchased at a discount but will be sold at market value.

Mathematically, the quantity and quality of a two-lot blend can be represented as:

$$W_1MC_1 + W_2MC_2 = W_bMC_b$$

$$W_1 + W_2 = W_b$$

where, W_1, W_2 = the weights of grains 1 and 2 before blending (bu)
MC_1, MC_2 = the moisture contents of grains 1 and 2 before blending (%)
W_b = the total weight of the blend (bu)
MC_b = the target moisture content of the blend (%)

Therefore, the quantity of the low MC grain can be determined as follows:

$$W_2 = W_1 \times (MC_1 - MC_b) / (MC_b - MC_2)$$

Example (using the formula above):

Assume that the desired final MC is 15.5% and that 9,500 bushels of corn are received by the elevator at 17.5% moisture from the field. Over-dry corn at 14% moisture is on hand, sold by other producers. How much 14% MC corn must be blended with the 9,500 bushels to obtain an average MC of 15.5%?

To determine the amount of 14% MC corn in blending, apply the formula above as follows:

$$W_2 = 9{,}500 \times (17.5 - 15.5) / (15.5 - 14.0)$$

$$W_2 = 12{,}667 \text{ bu}$$

It should be mentioned that there are some risks associated with blending grain. The further apart the two moistures are to be blended, the greater risk in storage will be. A blend of 17% and 14% MC grain lots will equalize to within 0.5 percentage point moisture, but a blend of 20% and 12% may never equalize closer than 1.5 to 2 percentage points. Accordingly, it is advisable to blend grain with small differences in MCs. A practical course of action is no more than a 4 percentage point spread in moistures of blended grains. Each kernel will never reach the average MC. Chances are there will be a group of wet kernels within the mixed grain that could develop hot spots. This group can start to spoil which will then spread. Considerable spoilage can occur during long-term storage.

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SAMMY SADAKA, Ph.D., P.E., P.Eng., is an assistant professor - Extension engineer with the University of Arkansas System Division of Agriculture located in Little Rock. **GRIFFITHS G. ATUNGULU** is an assistant professor and **GBENGA OLATUNDE** is a post doctoral associate with the Food Science Department located at the University of Arkansas in Fayetteville.

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