Bulletin 425

How To Determine

SHRINKAGE

In

GRAIN

Agricultural Extension Service
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TABLES

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How To Determine
SHRINKAGE In GRAIN

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The value of grains and feed stuffs is dependent upon the amount of dry matter they contain. Although feed analyses usually state the percentage of dry matter, grain quotations usually express the amount of moisture. This is important because one must keep in mind that only the dry matter has value.

It is understandable that grain quotations came to be stated in percentage of moisture content. High moisture causes grain to be worth less for several reasons. Such grain contains less dry matter, creates a storage problem, promotes insect and disease growth, makes processing difficult, may lower other related grade factors, increases transportation costs and creates a drying cost. Therefore, discounts are applied when certain limits of moisture are exceeded.

HOW SHRINKAGE IS CALCULATED

Wet grain is shrunk so that the quantity of dry matter is equivalent to that in the buying specifications. For example, buying specifications with 15.5 percent moisture amount to 84.5 percent dry matter. This is the key to calculating the amount of shrinkage. The percentages of dry matter at which grain prices are usually quoted in Ohio are shown in Table 1. For this reason, shrinkage is usually based on the amount of dry matter shown in the Table. The term "dry grain," as used in this bulletin, refers to grains containing the percentages of dry matter and moisture shown in this Table.

Table 1.—Grades Commonly Used in Quoting Grain Prices in Ohio

Kind of Grain	Grade	Dry Matter	Moisture
		(percent)	(percent)
Corn	2	15.5	84.5
Wheat	2	14.0	86.0
Soybeans	1	13.0	87.0
Oats	2	14.5	85.5

When high moisture grain is shrunk to a dry grain basis, two types of losses in weight occur:

1. Moisture loss
2. Dry matter loss

The amount of shrinkage caused by the removal of the excess moisture is determined mathematically.

Calculating the percentage of excess moisture in grain may be illustrated with shelled corn containing 20 percent moisture. Such corn, of course, contains 80 percent dry matter. In this illustration the shrinkage will be based on dry corn containing 15.5 percent moisture or 84.5 percent dry matter.

The calculation follows:

$100\% - 20\% = 80\%$ dry matter in the wet grain

$100\% - 15.5\% = 84.5\%$ dry matter in dry grain

$80\% \div 84.5\% = .94675$

$.94675 \times 100 = 94.675\%$

$100\% - 94.675\% = 5.33\%$ shrinkage due to moisture loss.

In addition to the moisture loss there is also a dry matter loss. This loss consists of the removal of chaff, bee's wing, parts of tip caps, fine parts of cracked kernels and dust caused by rubbing and polishing action. This loss results from transferring and drying the grain in removing the moisture. Elevators in Ohio report an average dry matter loss of about one-half of one percent. This amounts to one-half pound in 100 pounds of grain and correspondingly less per bushel. In some instances, of course, the loss exceeds one-half percent.

Thus, in this illustration in which 20 percent moisture shelled corn is shrunk to 15.5 percent moisture the total percentage shrinkage is:

1. Moisture loss	5.33 percent
2. Dry matter loss	.50 percent
Total shrinkage	5.83 percent

This shrinkage figure appears in Column 6, Table 2. All the percentages of shrinkage shown in Table 2 include one-half percent allowance for dry matter loss regardless of the amount of excess moisture.

This is the common practice in shrinking grain and is justified on the basis that the grain is transferred and dry matter particles are blown off equally in removing small and large quantities of moisture. Table 2 has been calculated to help readers better understand shrinkage losses.

Table 2.—Grain Shrinkage Chart

Percentage Shrinkage When a Unit of Grain is Dried to Selected Percentages of Moisture[1]

Percentage Moisture In Grain	Percentage of Shrinkage When Grain Is Dried to:					
	13.0% Col. 1	13.5% Col. 2	14.0% Col. 3	14.5% Col. 4	15.0% Col. 5	15.5% Col. 6
13.0	0	0	0	0	0	0
13.5	1.07	0	0	0	0	0
14.0	1.65	1.08	0	0	0	0
14.5	2.22	1.66	1.08	0	0	0
15.0	2.80	2.23	1.66	1.09	0	0
15.5	3.37	2.81	2.24	1.67	1.09	0
16.0	3.95	3.39	2.83	2.25	1.68	1.09
16.5	4.52	3.97	3.41	2.84	2.26	1.68
17.0	5.10	4.55	3.99	3.42	2.85	2.28
17.5	5.67	5.12	4.57	4.01	3.44	2.87
18.0	6.25	5.70	5.15	4.59	4.03	3.46
18.5	6.82	6.28	5.73	5.18	4.62	4.05
19.0	7.40	6.86	6.31	5.76	5.21	4.64
19.5	7.97	7.44	6.90	6.35	5.79	5.23
20.0	8.55	8.01	7.48	6.93	6.38	5.83
20.5	9.12	8.59	8.06	7.52	6.97	6.42
21.0	9.70	9.17	8.64	8.10	7.56	7.01
21.5	10.27	9.75	9.22	8.69	8.15	7.60
22.0	10.84	10.33	9.80	9.27	8.74	8.19
22.5	11.42	10.90	10.38	9.86	9.32	8.78
23.0	11.99	11.48	10.97	10.44	9.91	9.38
23.5	12.57	12.06	11.55	11.03	10.50	9.97
24.0	13.14	12.64	12.13	11.61	11.09	10.56
24.5	13.72	13.22	12.71	12.20	11.68	11.15
25.0	14.29	13.79	13.29	12.78	12.26	11.74
25.5	14.87	14.37	13.87	13.37	12.85	12.33
26.0	15.44	14.95	14.45	13.95	13.44	12.93
26.5	16.02	15.53	15.03	14.54	14.03	13.52
27.0	16.59	16.11	15.62	15.12	14.62	14.11
27.5	17.17	16.68	16.20	15.70	15.21	14.70
28.0	17.74	17.26	16.78	16.29	15.79	15.29
28.5	18.32	17.84	17.36	16.87	16.38	15.88
29.0	18.89	18.42	17.94	17.46	16.97	16.48
29.5	19.47	19.00	18.52	18.04	17.56	17.07
30.0	20.04	19.58	19.10	18.63	18.15	17.66
30.5	20.61	20.15	19.69	19.21	18.74	18.25

[1] All of the above percentages of shrinkage figures include actual moisture loss plus one-half percent for dry matter loss.

The percentage of shrinkage may be applied to pounds, bushels, tons and all other units of quantity.

Grain buyers commonly refer to shrinkage charts similar to that in Table 2 for speed and convenience in finding the percentage of shrinkage. Some charts show the amount of shrinkage for each one-tenth of one percent of excess moisture.

Another method of estimating the percentage of shrinkage is sometimes used—the "factor method."

Simply subtract the percentage of moisture in dry grain from the percentage of moisture in the high moisture grain and multiply the result by some selected factor. Factors selected by those who use this method commonly range from 1.2 to 1.3.

A comparison of the results of the two methods is illustrated in Table 3 when grain is being shrunk to 15.5 percent moisture from 16, 23 and 30 percent, respectively, using a factor of 1.25.

The illustration shows that when grain is shrunk from 23 percent to 15.5 percent moisture, a factor of 1.25 produces the same result as the equation method. However, when shrinking grain from 16 percent, the result is too small and from 30 percent the result is too large. This same type of inconsistentcy between the two methods occurs when other factors are selected.

Table 3.—Comparison of Shrinkage by Equation and Factor Methods

Moisture in Sample	Equation Method (Used in Table 2)	Factor Method (Difference in percentage X 1.25)
(Percent)	(Percent)	(Percent)
16	1.09	0.625
23	9.38	9.38
30	17.66	18.13

The factor method has the advantage of being easier, but it is not consistent with the more-accepted equation method shown in Table 2. The equation method includes a constant one-half percent dry matter shrinkage regardless of the amount of excess moisture. For this reason, no factor can be selected which gives results consistent with the equation method.

Whatever method is used in arriving at the percentage of shrinkage, the shrinkage is multiplied by the initial weight of high moisture grain. This amount is then deducted from the initial weight of the grain. Application of these calculations thus reduces the quantity of high moisture grain to a dry basis.

HOW TO OBTAIN A SAMPLE

A representative sample of the lot of grain is essential in determining the percentage of shrinkage in the lot.

The United States Grain Standards Act makes the Department of Agriculture responsible for grain grades and grading. The Department in its instructions sets forth the methods which are to be used by licensed inspectors and supervisors. Greatly simplified, these instructions for obtaining samples of grain from cars, trucks and wagons are explained below:

Samples are to be taken with a compartment bulk grain probe. The probe is to be inserted into the grain at an angle of about 10 degrees from the vertical with the slots closed. The probe is to be opened with the slots facing upward. While the slots remain open, the probe is to be moved up and down in two quick, short motions so that the openings will be filled. Then the probe is to be closed, withdrawn and the contents placed full length on a sampling cloth. Five or more such probings are to be made at well distributed parts of the car, truck or wagon. After the contents of each probing have been observed, the separate samplings are to be mixed for testing.

Whenever the percentage of moisture in the sample cannot be determined immediately, the sample is to be enclosed in a moisture proof container.

BASES FOR DETERMINING MOISTURE CONTENT

The United States Department of Agriculture has issued instructions for determining moisture in grain. These instructions, in simplified form, follow:

Moisture in wheat, barley and rye is to be determined after the dockage is removed. On the other hand, moisture in corn, oats, soybeans and grain sorghums is to be determined from the original sample as a whole. The air-oven method has been established as the authority, or standard, for determining the exact quantity of excess moisture in the sample. Except for this purpose, the method is rarely used because it requires a great deal of time and effort. Some device is selected which gives comparable results.

MOISTURE DISCOUNTS

Grain quotations are usually based on the specified amounts of moisture shown in Table I. Discounts are applied according to the percent of moisture that exceeds these amounts. Discounting compensates for the reduced amount of dry matter, detrimental effects of high moisture in the grain, and the cost of removing the moisture.

The reduced dry-matter value may be illustrated with 22 percent moisture shelled corn compared with 15.5 percent moisture corn priced at say $1.12 a bushel. Table 2 shows that the shrinkage is 8.19 percent, hence $1.12 times 8.19 percent equals $0.092 a bushel. To this, the cost of removing the moisture must also be included in arriving at the total moisture discount.

Until a few years ago, moisture discounts were nearly always shown as one figure. Today it is not uncommon for country elevator buyers to show the deduction broken down into two items, namely:

1. Shrinkage
2. Charge for drying the grain.

HOW TO DETERMINE SHRINKAGE IN EAR CORN

Although more corn in Ohio is being shelled on the farm, much is still delivered to the elevator as ear corn. When corn is sold in the ear, the determination of shrinkage is a more difficult task. An additional unknown is involved in ear corn, namely the "shell out."

The Shell Out Varies With:

1. Moisture
   a) Percentage of moisture in the kernels as well as the cobs. (See table 5.)
   b) Length of time in storage—during the storage the percentage of moisture in the cob declines at a faster rate than the percentage in the kernel. Hence the shelling percentage improves as the storage period increases.
   c) Rapid drying for a short period—this causes cobs to have more moisture at a given kernel moisture.
   d) Size of ears—at the same kernel moisture the larger ears have a somewhat higher percentage of moisture in their cobs than smaller ears.
2. Kernel loss in harvesting.

3. Percentage of shelled corn left in the crib when the ears are removed.
4. Quantity of husks remaining.
5. How well the ears are filled (including bird feeding).
6. Hybrid grown.
7. Growing season.

After corrections have been made for percentage of moisture, the largest probable causes for variation in shell out are the amounts of shelled corn left in the field and in the crib.

Ohio once had a law which established official weights for a bushel of ear corn. Upon recognizing the great range in variation in the shell out of various lots of ear corn, the law was repealed. Since then, there have been no official weights for ear corn in Ohio.

Methods Now Used to Determine the Quantity of Shelled Corn in Ear Corn Include:

1. Weighing the ear corn and dividing by the approximate number of pounds required to equal 56 pounds of shelled corn containing 15.5 percent moisture. The approximation must be based on a typical shell out for the amount of moisture found in the kernels. Table 4 shows the approximate number of pounds of ear corn required at selected levels of kernels to equal one bushel (56 pounds).

2. Shelling a sample of ears from the load. The kernels are weighed and the shell out is determined. The shell out of the sample is then applied to the entire load.

3. Shelling the entire lot of ear corn and weighing the shelled corn. This method, of course, is the most accurate, and the practice is increasing. It involves shelling the corn in the field, at the crib or at the elevator before the weighing is done.

The following illustrations show how to use Table 4 in estimating the bushels of corn:

Column 2. To estimate the bushels of shelled corn (56 lbs., 15½%) in 2,000 pounds of ear corn with 20% kernel moisture divide 2,000 by 74.8 = 26.7 bu.

Column 3. To estimate the bushels of shelled corn (56 lbs., wet) in 2,000 pounds of ear corn with 20% kernel moisture divide 2,000 by 70.4=28.4 bu.

Column 4. To estimate the bushels of shelled corn (56 lbs., 15½%) in 2,000 pounds of shelled corn with 20% kernel moisture divide 2,000 by 59.5=33.6 bu.

Table 4.—Estimated Pounds of Corn at Selected Moisture Levels to Equal One Bushel of Shelled Corn

Percentage Moisture In Kernels	Pounds of Ear Corn To Equal 56 Pounds 15.5% Moisture Shelled Corn	Pounds of Ear Corn To Equal 56 Pounds Original Moisture Shelled Corn	Pounds of Shelled Corn To Equal 56 Pounds 15.5% Moisture
Column 1	Column 2	Column 3	Column 4
15.5	68.5	68.5	56.0
16.0	69.5	68.7	56.6
16.5	70.1	68.9	57.0
17.0	70.8	69.1	57.3
17.5	71.4	69.3	57.7
18.0	72.1	69.6	58.0
18.5	72.7	69.8	58.4
19.0	73.4	70.0	58.7
19.5	74.1	70.2	59.1
20.0	74.8	70.4	59.5
20.5	75.5	70.6	59.8
21.0	76.2	70.9	60.2
21.5	76.9	71.1	60.6
22.0	77.7	71.3	61.0
22.5	78.4	71.5	61.4
23.0	79.2	71.8	61.8
23.5	79.9	72.0	62.2
24.0	80.8	72.3	62.6
24.5	81.6	72.5	63.0
25.0	82.4	72.7	63.4
25.5	83.2	72.9	63.9
26.0	84.1	73.2	64.3
26.5	84.9	73.4	64.8
27.0	85.8	73.7	65.2
27.5	86.7	73.9	65.7
28.0	87.6	74.2	66.1
28.5	88.5	74.4	66.6
29.0	89.4	74.7	67.0
29.5	90.3	74.9	67.5
30.0	91.3	75.2	68.0

One-half of one percent has been included as dry matter loss in columns 2 and 4.

MOISTURE RELATIONS VARY IN KERNELS AND COBS

Table 5 shows the relation of moisture in kernels to cobs at selected moisture levels. The percentages of moisture in the kernels and cobs are about equal when the growing ears are in the dough stage; also when the ears are dry. Between these two stages there is a wide and varying relationship in the percentage of moisture in the kernels and cobs. The maximum difference occurs at 28 percent kernel moisture when the cobs have 51.5 percent moisture. Under average conditions, stored ears, with 22 percent kernel moisture, have cobs containing 33.7 percent moisture. As drying continues, the cobs dry faster than the kernels. The amounts of moisture in the kernels and cobs tend to equalize during storage.

These changes in the amount of moisture in the kernels compared with the cobs complicate the problem of determining the number of pounds of ear corn required to equal a bushel. The varying amounts of moisture in the kernels and cobs have been taken into consideration in Table 4 in arriving at the pounds of Ear Corn to equal 56 pounds of shelled corn.

Table 5.—The Relation of Kernel and Cob Moisture Expressed as Percentage of Moisture

Kernel Moisture (percent)	Percentage of Moisture in the Cob	
	Corn from field (percent)	Corn from storage (percent)
14	15.0	12.9
15	16.8	14.4
16	19.0	16.2
17	22.2	18.3
18	26.6	20.8
19	31.1	23.8
20	35.1	27.2
21	38.8	30.5
22	42.0	33.7
23	44.0	
24	45.8	
25	47.5	
26	49.0	
27	50.3	
28	51.5	
29	52.5	
30	53.3	
31	54.0	
32	54.7	
40	59.0	
50	62.2	
60	64.7	
65	66.0	

Data in table selected from Purdue University, Agricultural Experiment Station Bulletin 599.