Chapter 15

On-Farm Drying and Storing

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Harvested grain is at its prime when it comes from the field to storage. Everything that is done from that time should help preserve that quality. Soybeans may be easily stored and dried in facilities that were designed for rice or wheat. Soybeans are easy to dry because air moves through them, at least relatively clean beans, more readily than many other grain types. They should be dried as quickly as possible to moisture levels of 13 percent or less. A moisture level of 11 percent is desirable if beans are to be kept longer than six months. Beans should also be cooled to avoid moisture collection throughout the winter season. Dry and cool beans are relatively safe from fungi and insects – the two primary potential sources for grain damage.

Figure 15.1. Properly designed and managed on-farm storage allows growers to optimize seed quality and market strategy.

Fungi and insects are both fueled by high moisture levels and are more apt to occur in trashy grain or in grain with a lot of damaged kernels. High temperatures and high humidities set up an excellent scenario for fungi to grow. Once grain is cooled down to 40ºF, the likelihood of fungi growth is much less. Fungi are the most important cause of soybean damage in storage. Soybeans have an excellent seedcoat, which helps protect them from insect assault. Insects are more likely to attack damaged beans – either from handling damage or being damaged by some other source, such as fungi.

There are several ways that the quality of soybeans may be reduced. Soybeans are susceptible to damage by handling. Rough handling by rigid conveyors or by dropping from large heights may damage beans. Handling damage potential becomes higher as the beans get drier and drier. The recommend minimum airflow rates for drying soybeans are in Table 15.1.

Table 15.1. Amount of Air Needed at Different Moisture Levels

11% to 13% moisture	.5 cfm per bushel
13% to 15% moisture	1 cfm per bushel
15% to 18% moisture	2 cfm per bushel
18% to 20% moisture	3 cfm per bushel

Drying of all grains is accomplished by the combination of air quality (equilibrium moisture content – the dryness of air) and air quantity. Air quantity is usually by far the cheaper of the two. The air quality may be enhanced by the addition of heat. Studies indicate that the heat should not be above 100ºF and the relative humidity of the air should not be below 40 percent to avoid grain damage. When

Figure 15.2. Typical centrifugal fan with heater and controls on an on-farm bin.

drying, air should be passed through the grain any time that the equilibrium moisture content of the air is lower than that of the grain. Table 15.2 may be used to determine the equilibrium moisture content. With careful management, soybeans may be dried without adding any heat. Care should be taken not to overdry the beans at the bottom of the bin by pumping very dry air through the beans. Air that has a lower equilibrium moisture content than the desired level for the grain should not be pumped through the grain for any length of time to avoid overdrying.

Soybean moisture level is critical for maintaining storage quality. Beans should be kept at moisture levels of about 12 percent or less. Access to an accurate moisture meter is highly recommended for bean storage. Moisture levels may also affect germination quality. Moisture-related problems will usually change the outside appearance of the kernel. The viability or germination of soybeans will often decline before there is any visual change in the appearance – and almost certainly if there are obvious appearance changes. Storage temperature plays an important role with moisture interaction. Warmer temperatures require drier beans in order to maintain the same quality. Seed beans should be kept at lower moisture levels. Moisture levels of 10 percent are recommended for long-term storage in the southern sections of Arkansas to a maximum of 12 percent in the northern edge.

Equipment Needed

It is imperative that the storage facility managers have some basic tools to measure the drying progress.

Air quality is best measured using a sling psychrometer. Humidistats are available on a number of bins but historically have been very inaccurate. Sling psychrometers are available from a number of sources for less than $100. Two excellent sources are Seedburo at (800) 284-5779 or www.seedburo.com and Forestry Suppliers, Inc., at (800) 647-5368.

A good-quality seed moisture meter is very helpful as well. This is a must-have item. If you don't have one, try to find a source nearby where you can take your beans and have them tested on a regular basis.

A manometer should be available to measure static pressure. This is the pressure the fan has to work against. The static pressure coupled with a fan chart will indicate the amount of air being moved. It is a good idea to install a port in the sub-floor underneath the grain to attach the hose onto for the manometer – a tubeless tire valve stem with the core removed makes an excellent attachment point. Manometers may be constructed using a ruler and clear plastic hose or may be purchased. An excellent source for manometers is Dwyer® Instruments, Inc., (219) 879-8000.

Each fan should have a performance table which indicates how much air can be moved at different levels of static pressure. As the level of beans gets deeper, the pressure increases. This means there is less air per bushel and that less air is being moved. Beans should not be placed in the bin too deep.

The following steps may be used to determine the acceptable level:

1. Measure static pressure with a manometer.
2. Determine the amount of air being moved, cfm, by the fan. This is usually done by going to a fan chart for the pressure measured above.
3. Determine soybean moisture level.
4. Look at Table 15.1 to determine cfm per bushel that is needed at that moisture level.
5. Limit the fill level to keep the cfm per bushel within acceptable limits.

Example:

1. Three inches of static pressure are measured.
2. From a fan chart – 20 HP centrifugal fan will move 16,500 cfm at 3 inches of static pressure. Fan charts vary because of fan blade and housing design, so try to find one for your particular fan.
3. Soybeans are at 15 percent moisture. From Table 15.1, one can see that about 1.5 cfm/bushel are needed.
4. 16,500/1.5 implies we can have up to 11,000 bushels in this bin.

Table 15.2. Approximate Moisture Content of Soybeans (Wet Basis) in Equilibrium with Air at Various Humidities and Temperatures (Calculated Using Henderson Equation)

Temperature	Relative Humidity (%)													
	25	30	35	40	45	50	55	60	65	70	75	80	85	90
35	4.7	5.5	6.4	7.3	8.2	9.2	10.2	11.3	12.5	13.8	15.2	16.8	18.8	21.4
40	4.6	5.5	6.3	7.2	8.1	9.1	10.1	11.1	12.3	13.6	15.0	16.6	18.6	21.1
45	4.5	5.4	6.2	7.1	8.0	8.9	9.9	11.0	12.1	13.4	14.8	16.4	18.3	20.8
50	4.5	5.3	6.1	7.0	7.9	8.8	9.8	10.8	11.9	13.2	14.6	16.2	18.1	20.6
55	4.4	5.2	6.0	6.9	7.8	8.7	9.6	10.7	11.8	13.0	14.4	16.0	17.8	20.3
60	4.3	5.1	5.9	6.8	7.6	8.6	9.5	10.5	11.6	12.8	14.2	15.7	17.6	20.1
65	4.3	5.1	5.9	6.7	7.5	8.4	9.4	10.4	11.5	12.7	14.0	15.5	17.4	19.8
70	4.2	5.0	5.8	6.6	7.4	8.3	9.3	10.2	11.3	12.5	13.8	15.4	17.2	19.6
75	4.2	4.9	5.7	6.5	7.3	8.2	9.1	10.1	11.2	12.3	13.7	15.2	17.0	19.4
80	4.1	4.9	5.6	6.4	7.2	8.1	9.0	10.0	11.0	12.2	13.5	15.0	16.8	19.1
85	4.0	4.8	5.6	6.3	7.1	8.0	8.9	9.9	10.9	12.0	13.3	14.8	16.6	18.9
90	4.0	4.7	5.5	6.3	7.1	7.9	8.8	9.7	10.8	11.9	13.2	14.6	16.4	18.7
95	3.9	4.7	5.4	6.2	7.0	7.8	8.7	9.6	10.6	11.7	13.0	14.5	16.2	18.5
100	3.9	4.6	5.3	6.1	6.9	7.7	8.6	9.5	10.5	11.6	12.9	14.3	16.0	18.3

Estimating Drying Costs

Drying costs may be estimated using the following equation(s):

$$\text{Fan motor cost/hr of operation} = (\text{Fan HP})\left(\frac{.7475\ \text{kW}}{\text{HP}}\right)\left(\frac{\text{Cost}}{\text{kW - hour}}\right)$$

Example:

20 HP fan with electricity costs at $0.08 kW-hr.
(No demand charges are applied here – they would need to be averaged into the kW-hour cost.)

$$\text{Fan motor cost/hr of operation} = (20\ \text{HP Fan})\left(\frac{.7475\ \text{kW}}{\text{HP}}\right)(\$0.08) = \$1.19$$

Drying costs to remove water:

$$\text{Fuel cost (\$/bu)} = \left(\frac{(\text{BTU/lb water})(\text{lb of water removed/bu})(\text{cost of fuel/unit})(100)}{(\text{BTU/unit of fuel})(\text{burning efficiency (\%)})} \right)$$

where LP gas has 92,000 BTU/gal, natural gas has 1,000 BTU/ft^3, electricity has 3,413 BTU/kW-h, and burning efficiency = 80% for LP and natural gas and 100% for electricity.

BTU/lb water values vary from 1,000 to 1,400, depending on conditions and the amount of moisture available near the outside of the kernel. Value may be estimated using 1,200 BTU/lb water.

Moisture Content	Soybeans	(continued)	
%	lb/bu		
5.0	54.95	15.0	61.41
5.5	55.24	15.5	61.78
6.0	55.53	16.0	62.14
6.5	55.83	16.5	62.52
7.0	56.13	17.0	62.89
7.5	56.43	17.5	63.28
8.0	56.74	18.0	63.66
8.5	57.05	18.5	64.05
9.0	57.36	19.0	64.45
9.5	57.68	19.5	64.85
10.0	58.00	20.0	65.25
10.5	58.32	21.0	66.08
11.0	58.65	22.0	66.93
11.5	58.98	23.0	67.80
12.0	59.32	24.0	68.69
12.5	59.65	25.0	69.61
13.0	**60.00**	26.0	70.55
13.5	60.35	27.0	71.51
14.0	60.70	28.0	72.51
14.5	61.06	29.0	73.53
		30.0	74.58

If we look in the table above for 20 percent soybeans, we can determine that there are 5.25 pounds of water per bushel above the value for 13 percent soybeans. The following is an estimate assuming LP gas was used for drying at a cost of $0.65/gallon and initial moisture 20 percent dried down to 13 percent.

$$\text{Fuel cost (\$/bu)} = \left(\frac{(1200\ \text{BTU/lb water})(5.25\ \text{lb of water removed/bu})(\$0.65)(100)}{(92{,}000\ \text{BTU})(80)} \right) = \$0.0556$$

Aeration Maintenance

Even after drying soybeans down to an acceptable moisture level, care must be taken to keep the beans at this level. Soybeans have the ability to lose and regain moisture more readily than many other grains. This may account for the fact that moisture migration and condensation seem to occur faster in soybeans. Moisture will be drawn in from outside the bin, and natural convection currents will set up – resulting in an accumulation of moisture in the center and top area of the grain. If the center area is allowed to stay moist for any length of time, it is an excellent area for fungi growth if temperatures become favorable.

Aerate with natural air once the grain is below 13 percent. The grain should be cooled as much as possible with early fall conditions. Cooling air should be checked for humidity, being careful to aerate when humidity is below about 60 percent, or better yet when the EMC content is at or below the grain target moisture level. Aeration with high humidity air will add moisture back to the grain. Accumulated moisture can typically be managed very easily if the grain is aerated every couple of weeks. As the grain temperature in the bin stabilizes, all the beans get about the same temperature, the moisture migration problem will lessen.

Probe the bin periodically to check for insect infestation and grain temperature increase. Grain temperature increase usually means moisture migration. Aerate whenever this is detected. If the problem is in the center of the bin and aeration is not effective, moving the grain to another bin to solve the problem may be necessary. Problems in the center of the bin usually indicate that a lot of fines and/or trash accumulated in this area during filling.

Fall Aerate continuously at any time when the equilibrium moisture content is acceptable and air temperature is 10ºF to 15ºF cooler than grain temperature until grain is cooled to 40ºF.

Winter Aerate about every two weeks when air temperature is within 10º of grain temperature. Try to get at least 24 hours of drying time per two week period.

Spring When mean daily temperatures show steady increase, aerate continuously whenever air temperature is 10ºF to 15ºF warmer than grain temperature until grain temperature reaches 60ºF to 65ºF.

The key to excellent on-farm soybean storage is controlling the moisture level in soybeans. This requires excellent management coupled with an adequate aeration system.

Note: Refer to MP213, *Grain Drying*, for additional details.