Soybean Drying, Handling and Storage

Kenneth Hellevang
Extension Engineer

Soybeans usually are traded on a 13 percent moisture basis, so harvesting, storing and selling soybean as close to 13 percent moisture (wet basis) as possible is to the farmer's advantage. Soybean that are wetter than 13 percent moisture are likely to mold under warm conditions, and buyers usually apply shrink factors and drying charges when wet beans are delivered.

On the other hand, soybeans that are drier than 13 percent moisture are more likely to split during handling and, since they weigh less, fewer bushels are available for sale. If the temperature of the stored beans is kept below about 60 F, soybeans usually can be held for at least six months at 13 percent moisture without mold problems. For storage under warmer temperatures or for storage times longer than six months, however, the recommended moisture content is 11 percent.

Storage Management for 11 to 13 Percent Moisture Soybean

Soybean that are harvested at 11 to 13 percent moisture can be placed directly into ordinary

storage bins equipped with simple aeration systems (perforated ducts or pads and relatively small fans). The suggested winter storage temperature for grains and oilseeds in the upper Midwest is 20 to 30 F. Since soybeans usually are harvested at temperatures well above 30 F, cooling them by operating aeration fans during cool weather is necessary.

Rather than waiting until outdoor temperatures drop to 20 to 30 F before cooling stored beans, cooling them in 10- to 20-degree stages as average temperatures drop in the fall is best. For example, if beans are harvested at 55 F, you could wait a few weeks until average outdoor temperatures drop to 40 F and run the fans long enough to cool all the beans in the bin to 40 F. Then shut the fan off for a few more weeks and repeat the cycle when average outdoor temperatures fall to about 25 F.

The airflow provided by aeration fans usually is expressed as cubic feet of air per minute per bushel of beans, or cfm/bu. You can estimate the amount of fan operation time to cool an entire bin of beans by dividing 15 by the airflow in cfm/bu.

For example, many on-farm storage bins have an airflow rate of about 0.2 cfm/bu, so the cooling time would be 15 divided by 0.2, or 75 hours, which is about three days. You can use this formula to estimate cooling time, but you should measure the bean temperature at several different points in the bin to make sure that cooling is complete.

When you are operating aeration fans to cool beans that are 11 to 13 percent moisture, you don't need to worry too much about relative humidity. Beans near the point where air enters the bin will rewet some during very humid weather, and some overdrying will occur during very dry weather, but if fans are operated no longer than necessary to cool the bin, the overall moisture change will be quite small.

Changing the moisture of a crop takes about 50 times as long as changing its temperature does, which means you can move a temperature front through 50 feet of beans by the time you've changed the moisture of a 1-foot layer. If you are concerned about operating the fan during weather that is too humid or too dry, however, you can install controls that will operate the fan only during weather conditions that do not cause drying or rewetting.

Keep in mind that these types of controls will limit the time that the fan operates, and cooling the entire bin will take longer than cooling would without the controls.

Once soybeans have been cooled to 20 to 30 F, check them every two to four weeks during winter months to make sure the temperature is stable and no mold, insect and crusting problems are developing. If you find problems, or if bean temperature has moved above or below the desired range, operate the aeration fan during 20 to 30 F weather to run a temperature front through the bin. If you need to

hold the beans into spring and summer, increase your frequency of checking the bins to every two weeks. But unless a problem develops, operating the aeration fans is not necessary.

If you do need to aerate during spring or summer, do so during the coolest weather available and make sure that you keep bean temperature less than 60 F.

When spoilage problems develop in stored beans, they often start in pockets of accumulated fines (small pieces of broken seeds, weed seeds and stem material) and foreign material. This material is difficult to aerate and it is often wetter and more susceptible to mold growth than whole seeds.

Try to keep fines and foreign material out of the bin by setting combines for maximum cleaning or by running beans through a grain cleaner on the way into the bin. Or at least prevent the fines and material from accumulating in one spot by using grain spreaders to fill bins, frequently moving spouts during bin filling or coring bins (removing some beans through the center unloading sump) after they are full.

For more information about grain and oilseed storage, obtain "Management of Stored Grain with Aeration" (publication AG-FO-1327) from the University of Minnesota Distribution Center or "Crop Storage Management" (publicationAE-791) from the NDSU Distribution Center.

Soybean Handling

Soybeans are subject to splitting during handling, so handle them gently. Belt conveyors, bucket elevators and drag or mass conveyors provide the gentlest handling. But normal grain augers can be used if they are operated slowly and at full capacity, and pneumatic or air-type conveyors can be used if the air-to-grain ratio is set properly and lines are laid out with a minimum number of very gradual curves.

Avoid long drop heights in bean handling by frequently adjusting the position of conveyors or using bean ladders or other devices that break long drops into a series of shorter drops. One handler of food-grade soybeans recommends 10 feet as the maximum height for any single drop.

Artificial Drying

Most years, fall weather conditions in the upper Midwest will dry soybeans to 11 to 13 percent moisture in the field. But some years, weather conditions prevent soybeans from drying to 13 percent moisture, and sometimes growers harvest at moistures greater than 13 percent to avoid the harvest losses that can occur at lower moisture contents.

Soybeans can be harvested without too much damage up to about 18 percent moisture. If soybean is harvested at a moisture content much above 13 percent, artificial drying is necessary.

Not much research has been published on soybean drying. Most drying recommendations are based on limited experience or are extrapolated from corn drying recommendations. In most cases, dryers that were designed for corn can be adapted for use with soybean.

Natural-air drying: Using unheated air to dry soybeans usually works well, but it is a slow process (four to six weeks, depending on initial moisture, airflow and weather). Bins used for natural-air drying should have fully perforated floors and fairly large drying fans. Fan power requirements depend on desired airflow and depth of beans. For example, delivery of 1 cfm/bu (cubic feet of air per minute per bushel of beans in the bin) through an 18-foot depth of soybeans would require about 0.6 horsepower (hp) per 1,000 bushels of beans in the bin, while delivery of 1.5 cfm/bu through 18 feet of beans would take about 1.6 hp/1,000 bu.

Management of natural-air soybean dryers is similar to that for natural-air corn dryers, except that soybean moisture values need to be about 2 percentage points lower than those recommended for corn.

In southern Minnesota, use an airflow rate of 1 cfm/bu to dry 17 to 18 percent moisture beans, 0.75 cfm/bu for 15 to 17 percent moisture beans and 0.5 cfm/bu for 13 to 15 percent moisture beans. In North Dakota and northern Minnesota, higher airflow is needed because fewer days are available for drying in the fall.

In northern areas, use 1 cfm/bu to dry soybeans that are 16 percent moisture or less, 1.25 cfm/bu for 17 percent moisture beans and 1.5 cfm/bu for 18 percent moisture beans. See "Natural-Air Corn Drying in the Upper Midwest" (publication BU-6577), which is available from the University of Minnesota Distribution Center, or "Natural-Air/Low-Temperature Crop Drying" (publication EB-35) from the NDSU Distribution Center for information on equipping and managing natural-air dryers.

Because natural-air drying is a slow process, using one bin to dry both beans and corn in the same year will be difficult. Don't plan on having the beans dry before corn harvest unless the soybeans are only slightly wetter than 13 percent or unless you use a shallow drying depth.

Low-temperature drying: Early in the fall, especially in years with warm, dry weather, drying soybeans to less than 13 percent moisture is possible with no supplemental heat (see previous section on natural-air drying). However, late in the fall, or in years with cool, damp weather, soybeans might not dry to 13 percent and adding a small amount of supplemental heat to the air in natural-air dryers might be helpful. Do not heat the air more than 3 to 5 degrees, though, or you will overdry the beans and you might cause an increase in splitting. Research has shown that exposing soybeans to relative humidities of less than 40 percent can cause excessive splitting.

For every 20 degrees that you heat air, you cut its relative humidity approximately in half, so producing relative humidities less than 40 percent doesn't take very much heat.

Some alternatives to adding supplemental heat to natural-air drying bins include:

- Turning off the fan when the weather gets cold in the fall, keeping beans cold during winter and resuming drying when average temperatures climb above freezing in the spring.
- Installing bigger fans so you can finish drying earlier in the fall when weather is better.
- Using manual or automatic controls to turn off the fan during periods of high humidity. Fan control will increase the amount of time required for drying, but it will result in drier beans.

High-temperature drying: Many kinds of gas-fired corn dryers can be used to dry soybeans, but be careful. Soybeans split easily if they are dried too fast or are handled roughly. Set the drying air temperature lower than you would for corn and avoid dryers that re-circulate the crop during drying.

Column-type dryers often be can operated at 120 to 140 F without causing too much soybean damage, although some trial and error might be required to set dryers properly. Examine beans leaving the dryer carefully and reduce the temperature if you're getting too many splits.

If the soybeans will be saved for seed, keep drying temperatures under 110 F to avoid killing the embryo.

Don't forget that crops dried in gas-fired dryers must be cooled within a day or so to remove dryer heat. This can be done in the dryer or aerated storage bins. Stored beans should be aerated again later in the fall to cool them to 20 to 30 F for winter storage.

Immature, Frosted or Green Beans

In years when frost kills soybean plants before the seeds are fully mature, make sure you remove as much chaff and green plant material as possible before binning the beans. Immature beans can be stored without significant molding, but concentrations of green chaff can lead to heating in storage.

Although producers have heard that green soybeans eventually will turn yellow in storage, the color change observed in a University of Minnesota laboratory study was minimal. Storing green soybeans for a few months after harvest still might be worthwhile to avoid the high discounts that are applied in years when large quantities of green beans are delivered during harvest. Just make sure that any green beans going into storage are clean, evenly distributed throughout the bin and cooled as soon as possible after harvest.

Reconditioning Overly Dry Soybeans

In years with exceptionally warm, dry falls, soybean sometimes is harvested at moisture contents well under 13 percent moisture. Although adding water to increase soybean moisture is illegal, given enough time and a high enough airflow per bushel, increasing the moisture content of soybeans is possible by aerating them with humid air. But here are some practical concerns and limitations:

- The process is quite slow, even with the high airflow per bushel (0.75 to 1 cfm/bu) available on bins equipped for drying. It will be similar to the speed of drying. Accomplishing significant reconditioning would be difficult using the low airflow aeration systems common on storage bins.
- Fan control is tricky and some beans could end up too wet for safe storage.
- You are likely to end up with layers of wet and dry beans unless you can find some way to mix them in the bin or during unloading of the bin.
- Swelling that accompanies rewetting will increase stress on bin walls.

The table of equilibrium moisture values shows the moisture content that soybeans would reach if exposed to different combinations of temperature and relative humidity for long periods of time. If you continuously aerated a bin of beans, they would tend to lose moisture during periods of low humidity and gain moisture during periods of high humidity.

To recondition soybeans to 13 percent moisture during normal fall temperatures of 30 to 60 F, you would need to control the fan so it operates during weather that has an average relative humidity of 65 to 70 percent.

The table indicates that bean moisture increases sharply as relative humidity increases, which means that rewetting a layer of soybeans to a moisture content that is too high for safe storage is quite easy.

Equilibrium moisture values (percent wet basis) for soybeans.

	Relative humidity (percent)				
Temperature	**50**	**60**	**70**	**80**	**90**
(F)					
32	10.0	11.8	13.7	16.2	19.8
40	9.8	11.5	13.5	16.0	19.6
50	9.5	11.2	13.2	15.7	19.4
60	9.2	11.0	13.0	15.4	19.1
70	8.9	10.7	12.7	15.2	18.9
80	8.6	10.4	12.5	15.0	18.7

During reconditioning, the moisture of the whole bin doesn't change at once. A rewetting zone develops and moves slowly through the bin in the direction the airflow is moving. This is similar to the way a drying zone moves through a drying bin.

In most cases, not enough high-humidity hours are available in the fall to move a rewetting zone all the way through the bin. And in many cases, depending on how the fan is controlled, the parts of the bin that have been rewetted will be too wet for safe storage.

Mixing the wet layers with the dry layers would be best to reduce spoilage risk and avoid drying charges for the wet layers when the beans are sold.

Mixing can be accomplished to a limited extent by emptying the bin and moving the beans through a grain-handling system. The most effective way to mix the beans, though, would be to use an in-bin stirring system. In fact, bin dryers equipped with stirring augers are a good choice for reconditioning soybeans.

If the initial moisture content of the beans is 10 percent or less, controlling the fan so it only runs when the relative humidity of the air reaching the beans is greater than about 55 percent should result in rewetting. If you use a single humidistat to turn the fan on anytime humidity is greater than 55 percent, average humidity during the hours the fan operates should be well above 55 percent and the beans are likely to rewet to at least 13 percent.

Since humidity is almost always higher at night than it is during the day, an alternative to a humidistat would be a timer set to run the fan only during nighttime hours.

If you aren't equipped to mix beans after reconditioning, you need to avoid rewetting them to moisture levels that are too high for safe storage. Approaches to prevent excessive rewetting include:

- Reducing the humidity setting on the humidistat that controls the fan so the fan runs during drier conditions

- Adding a second humidistat that stops the fan when relative humidity reaches very high levels
- Installing a sophisticated microprocessor-based controller that monitors both temperature and humidity and only runs the fan when air conditions will bring the crop to the desired moisture content (for either drying or rewetting)

The disadvantage of the last two approaches is that the fan doesn't run as many hours as it would with a single-humidistat control and less total moisture would be added. Running the fan at high humidities and then mixing the wet and dry beans would result in greater average moisture content.

Reconditioning time depends primarily on airflow per bushel and weather conditions. It is fastest when airflow per bushel is high and air is warm and humid. Reconditioning will be most successful in a bin equipped as a drying bin – one that has a fully perforated floor and a fan that can deliver at least 0.75 cfm/bu.

Even with this airflow, moving a rewetting front all the way through the bin probably would take at least a month of fan operation. Keep in mind that you can't run the fan continuously because in a typical fall, continuous fan operation would result in drying rather than rewetting.

Soybeans swell when they absorb moisture, and experience during floods indicates that soaking the bottom few feet of beans in a bin can result in enough

pressure to rupture bin walls. We don't have enough information on reconditioning soybeans through use of airflow to know whether this procedure can damage bins, but the process definitely will increase stress on the walls. Using a vertical-stirring auger to mix layers of dry and wet beans might be one way to reduce outward pressure generated during rewetting.

To increase chances of success in using airflow to recondition soybeans:

- Use a bin equipped with a fully perforated floor and a fan that can deliver at least 0.75 cfm/bu.
- Use a bin equipped with stirring equipment if it is available. If stirring equipment is not available, consider transferring the beans to another bin to mix the wet and dry layers.
- Use timers, humidistats, programmable controllers or some other type of automatic control to limit fan operation to weather conditions that will cause rewetting.
- Keep reconditioned beans cool (20 to 30 F is the suggested winter-storage temperature in the upper Midwest) to reduce chances of spoilage.
- Watch carefully for signs of moldy beans and excessive stress on the bin.

Food or High-value Soybean

More care is required with high-value soybean primarily to minimize the amount of cracked skins and beans. The optimum moisture content for harvest is about 13 to 15 percent. At moisture contents below

about 13 percent, more beans split, germination is reduced due to more damage during harvest and handling, field loss will be greater and producers see a loss of about 1.1 percent per point of moisture below 13 percent due to less weight.

To minimize damage during handling, belt conveyors are preferred to augers. If augers are used, they should be operated at a slow speed and be kept full. Pneumatic conveyors can be used if the proper air-to-grain ratio is maintained, gentle curves are used in the conveying tubes and a low conveying velocity is used. Drop heights should be minimized, so bean ladders are recommended in bins or other locations where the beans may fall during conveying. Cold beans are more susceptible to damage during handling.

Use care in drying beans because much of the damage that occurs during handling is due to stresses created during drying. Damage during drying occurs when the relative humidity of the drying air is below about 40 percent.

Generally, the drying air in a high-temperature dryer should not be heated more than 20 degrees to minimize the potential for damage to the seed coat. One study showed that with a 100 F drying temperature,10 to 60 percent of the skins cracked and 5 to 20 percent of the beans cracked. Another study showed about 15 percent of the seed coats cracked with the drying air at 40 percent relative humidity and 30 percent of the seed coats cracked with a 30 percent relative humidity.