Aeration of Grain in Storage

Cooperative Extension South Dakota State University

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AERATION OF GRAIN IN STORAGE

SOUTH DAKOTA
OFFICE OF ENERGY POLICY

CONTRACTOR:
COOPERATIVE EXTENSION SERVICE
SOUTH DAKOTA STATE UNIVERSITY
AERATION OF GRAIN IN STORAGE

Farm stored grain represents a sizeable investment. An aeration system that is properly installed and maintained will help protect that grain from deterioration. A relatively small investment in an aeration system will increase the probability that the $20,000 to $50,000 of stored grain will be in good condition when it is time to market the crop.

As the size of storage structures increase, keeping grain in condition becomes more difficult. The potential loss from poor management of the grain in those structures also increases. An aeration system managed along the guidelines provided here will reduce risks to stored grain, but it will not prevent all problems. There is no substitute for the observation and attention that the careful operator will give his stored grain.

What Is Aeration?

Aeration is the practice of moving a small volume of air through grain to control its temperature. Airflow rates of 0.1 to 0.25 cubic foot per minute (cfm) of air per bushel (bu) of grain in storage are typical. These rates are low when compared to those used in drying systems, consequently grain temperature can be changed with minimal change in its moisture content.

Equipment needed to operate an aeration system includes fan and motor to move the necessary amount of air, duct work, and a perforated duct or floor system to distribute air through the grain.

Why Is Aeration Important?

Grain stored in bins equipped with an aeration system is easier to observe and control than grain stored in a bin without one. Air moving through the grain controls its temperature so the danger of spoilage is less. In addition the odor of the air leaving the bin gives an indication of the condition of the grain.

Should grain stored in a bin without aeration start to go out of condition, the only option is to transfer the grain to another bin. This grain turning will cool the grain and will break up those pockets of grain going out of condition or in which insects are starting to work. Grain from different parts of the bin will be blended resulting in more uniform moisture content and temperature throughout the bin.

Grain turning has advantages but it does require that an empty bin be available. This increases the cost of the storage structures slightly. Turning grain involves considerable time and labor expense. And there is the danger of increasing kernel damage each time grain is handled.

An aeration system can provide many of the advantages of turning grain at a relatively low cost and with a low labor requirement. By first cooling the grain and then maintaining uniform temperatures throughout the bin insects are less likely to develop and grain will maintain its market grade longer.

An Aeration System Cools The Grain

The primary purpose of an aeration system is to keep the grain in condition so it can be used or marketed as planned. Grain cooling and temperature control increases the time that grain can remain in storage before it will drop one market grade in quality (Table 1). Note that the allowable storage time increases as the grain gets drier and cooler. A 10°F temperature drop nearly doubles the allowable storage time. While storage times for corps other than corn are not known, the principle of increasing storage time with cooler temperatures will hold true.

As grain is aerated a cooling front develops in the bin (Figure 1). Grain near the point where air enters cools first and the last to cool is the grain farthest from that point. The cooling front is the zone where cooling is actually occurring. It moves through stored grain in the direction air flows (Figure 1). Always aerate until the cooling front has moved completely through the grain. Take the grains temperature to determine when that has occurred.

<table>
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<th>Corn temperature</th>
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<td>6</td>
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</tbody>
</table>

Boxed values indicate example in text. Calculated from research completed at USDA Grain Storage Research Laboratory, Ames, Iowa. Based on 0.5% dry matter loss from kernels with normal harvest damage; kernels with greater damage will spoil two to five times faster.
Figure 1. A cooling front is established in a bin being cooled. Grain is cooling within that front. Grain closer to the air source has already cooled while that farther away is still warm.

Aeration fans can either move air up or draw it down through the grain. For a system moving the air up insert a thermometer 6 inches into the grain several places in the top of the bin. When air is drawn down measure the temperature of the air leaving the fan. The temperature will remain nearly constant until the cooling front reaches the thermometer. The temperature will drop relatively rapidly as the cooling front leaves the bin. It will then remain constant as the cooler temperature and aeration can be stopped.

Because of its ability to cool grain an aeration system can help to improve the timeliness of corn or sorghum harvesting. Some years grain does not dry in the field. However, it must be harvested before adverse weather greatly reduces yield. Such grain can be stored in a temporary storage structure, or even in a pile on the ground. Aeration is used to keep it cool and increase the allowable storage time. The aeration system will permit an earlier harvest and still allow use of an energy efficient drying method to prepare the crop for final storage.

Example: Corn is harvested at 24% moisture content and placed in temporary storage. Aeration is used to cool it to 40°. How long can it be kept in good condition?

Solution: Assuming it has normal harvest damage, 24% moisture content corn at 40° will lose one market grade in quality after 36 days. (Table 1).

Example: After 10 days in temporary storage the same corn is rapidly dried to 15% moisture content and stored in an aerated bin at 35°. How long can it be stored?

Insect activity is greatly reduced when grain is cooler than 60° especially if cooling is uniform. However, pockets of warm grain may develop and all stored grain needs to be checked periodically for insects.

One final advantage to cooling by aeration: it provides time for sound decision making should a storage problem develop. When heating or grain deterioration is detected start the aeration system and run until all grain is cool regardless of weather conditions. The rate of deterioration is slowed which allows more time to determine the extent of the problem and to evaluate feeding or marketing alternatives.

An Aeration System Provides Uniform Temperatures To Control Moisture Migration

An aeration system not only cools grain in storage but also evens out temperature differences throughout the bin. When those temperature differences are allowed to remain, moisture migration may result.

Moisture migration is a natural process that is the result of convection currents of air between the grain kernels. Air near the bin wall is cool during the late fall and winter months. It is heavier than warm air and has a tendency to settle along the bin wall.

At the same time, because grain is a relatively good insulator, air near the center of the bin is still warm and has a tendency to rise. As a result a convective current of air is set up in the bin. Air settles along the walls, moves toward the center and rises (Figure 2). As the air warms, it picks up and holds more moisture from the grain. However, as warm air reaches the cool or top layers of grain it no longer can hold as much moisture and the moisture level of the grain will rise in that area. An area of high moisture grain is created near the center at the top of the bin.

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Temperature differences that cause moisture migration are caused by natural cycles in air temperature. Other temperature differences in the bin result from the way it was filled. Grain going through a batch dryer is added to the bin in layers that may differ in temperature. Grain that goes into storage directly from the field will also vary in temperature depending on weather conditions and on the time of day when it is harvested. An aeration system will remove these temperature differences before mold and insects can infest localized warm pockets.

**How Should An Aeration System Be Operated?**

**Cool Grain In The Fall**

The most critical time to operate the aeration system is during cool weather immediately after the grain is stored. Rapid cooling reduces the danger of spoilage, however cooling the grain in steps can save energy and money over continuous fan operation.

Check grain temperature as it enters the bin. Start aeration fans as soon as the average air temperature is 10° cooler than the grain. Operate until the cooling front has passed through the bin and shut the fans off. Restart aeration when the average air temperature is again 10° cooler than the grain. Continue that procedure until all grain is 35°-40°.

Once a cooling cycle has started, operate continuously regardless of weather conditions. Do not worry about rewetting grain during high humidity periods. Any small amount of grain that is rewet slightly will be dried as soon as weather conditions change.

The time required to move a cooling front through the grain depends on the rate of air movement. The hours required for one temperature change can be estimated by dividing the airflow rate (cfm/bu) into 15. An airflow rate of 0.1 cfm/bu will take 150 hours (6.25 days) to cool the bin contents.

**Observe The Grain During The Winter**

Winter management of stored grain is mostly observation. Operate the aeration fans for a short time on mild days. That will dry any condensation in the motor and allow you to check for a musty smell in the air leaving the bin. This would indicate mold growth.

Enter the bin and check the grain weekly. Probe the contents to find hot spots, compacted areas, insects and mold growth. Look for crusted or sticky grain on the surface and for condensation from the roof. If any of these are found it indicates the grain may be going out of condition. Start the fan to thoroughly cool the grain. Investigate further to determine the extent of the problem and decide how the grain can be marketed.

Cover the fan with a commercial cover or tarp to keep out rodents and to reduce the chimney-effect that would draw air through the bin and increase moisture migration.

**Warm Grain In The Spring**

Continue checking the grain weekly throughout the spring. Moisture migration that has occurred during the winter will become more evident as the surface of the grain warms in the spring.

The extent of moisture migration cannot be predicted, but for an example let’s assume the surface grain is at 20% moisture. If we also assume that no heating has occurred and that surface grain temperatures do not exceed 35° during the winter, 20% grain has an allowable storage time of 1230 days (minus any loss before going into storage). In the spring grain on the surface will warm with outdoor temperatures and will approach the average air temperature. Twenty percent moisture corn at 60° has only 28 days of allowable storage (minus that lost in fall and winter) and will likely spoil unless checked frequently. The problem has developed over the winter but only became obvious as temperatures warm in the spring.

If grain has been cooled to 35° to 40° and is to be held over the summer, warm it to 50°-60° in order to prevent moisture migration. This migration is the reverse of that occurring during the winter. Do not warm over 60° as this will encourage spoilage. As in the fall, aerate in 10° steps based on outside air temperature.

In the spring, warm moist air is entering cool grain. Any time warm air enters cool grain condensation may result. Condensation on the grain will not be a problem if the warming front is moved completely through the bin. Operating in 10° steps will help to reduce condensation. To repeat, do not stop warming until the warming front is through the grain or a wet zone may be left in the grain.

**Which Direction Should The Air Move?**

An aeration system can be set to either blow air up or to draw it downward through the grain. Advantages to blowing the air up include:

1. The warmest area is near the top and can be checked easily. It is not deep in bin.
2. More natural cooling occurs because the warmest grain is exposed to cooler conditions at the top of the bin.
3. Warm grain can be added on top of cool grain without the danger of moving warm moist air into cool grain.
4. The heat added to the air by the fan and motor reduce the possibility of rewetting grain.
5. Areas of caked grain that may develop during aeration may be easier to spot during observation. They will be on top, not at the bottom of the bin.
6. Fines will not plug perforations as may happen when air is drawn down through the grain.

Advantages to drawing air down through the grain include:

1. No condensation on roof as can occur with upward air movement.
2. Will not pick up snow and blow it into the bin.
3. Any rewetting that occurs will be over a wide shallow depth of grain, not confined to the surface of the perforated ducts.
4. Once the cooling front has passed through the grain the top grain will be the coolest in the bin. Thus air does not pass from warm into cool grain.
5. Solar energy collected under the roof helps to control humidity.
6. Air can be concentrated around hot spots by laying a trap on top of the grain.
Match The Fan To The System

Select a fan that will deliver the amount of air you need against the static pressure the bin will develop.

The more air that is provided to the bin the faster it will cool (See Cool Grain In The Fall). A larger fan may seem desirable in order to provide more air. However, as airflow rate (cfm/bu) increases the static pressure also increases. A doubling of the airflow rate more than doubles the static pressure that the fan must develop (See FS 773 Fan Selection For Grain Drying and Aeration). Both static pressure and air volume determine how much power a fan will require. The aeration system will have lower operating costs if smaller fans pushing less air are used over a longer period of time.

Make sure ducts have enough cross sectional area so that the average air velocity in the ducts is low. That will help reduce pressure drop through the duct. To find the square feet of cross-sectional area needed in a duct divide the total airflow rate (cfm) for the bin by 1500. For long ducts divide the airflow rate by 1000.

Either perforated floors or ducts can be used for air distribution. For uniform aeration, space the ducts so that the longest path for air flow is not more than 1.5 times the shortest path for air flow (see Figure 3). To find that total perforated surface area needed, divide the airflow rate for the bin by 25. Assume that only 80% of a tube duct's circumference is available for aeration. Ducts should have at least 7% open area.

Other Management Helps
Aeration Systems Work Better

Screen out fine material and foreign matter before placing grain in storage. Such materials block the flow of air through grain. When allowed to accumulate these materials usually have a higher moisture content and will spoil more rapidly than whole grain. Molds and insects attack cracked kernels and other fine material before sound kernels will be affected. Material removed by the screen can be used for cattle feed.

Use a grain distributor when loading the bin. Without a distributor fine material accumulates directly below the filling spout where it blocks airflow passages. With a distributor those fines are spread throughout the bin permitting more uniform air flow. Fine material is less likely to cause grain deterioration if spread throughout the bin.

Do not peak grain in a bin. Little storage capacity is added and moisture migration will tend to increase. In addition air flow rate will be less through the center of the bin so less cooling will take place. The combination of high moisture grain and reduced airflow encourages spoilage.

Recommendations:
An aeration system can help preserve grain quality but only if it is used properly. This is just one management tool that you can use to keep stored grain in good condition. When planning and operating an aeration system:

a) Use low airflow rates to lower capital and operation costs.
b) Cool the grain using 10° steps as soon as it is placed in storage.
c) Maintain cool temperatures to reduce moisture migration.
d) Check grain weekly for mold and insects.
e) Warm grain in the spring using 10° steps. Move the warming front entirely through the bin.
f) Plan for adequate size in duct work and other aeration components.
g) If a storage problem develops aerate until all of the grain is cool.