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G84-692 Aeration of Stored Grain (Revised April 1993)

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Aeration of Stored Grain

This NebGuide discusses the role of aeration as part of a comprehensive management program for maintaining the quality of stored grain.

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Grain is stored for a variety of reasons including expectations of higher prices and for use as animal feed. Regardless of the reason, a comprehensive management program is required to maintain grain quality. This includes: 1) making sure that the grain going into storage is dry, clean and in good condition; 2) regularly inspecting the grain to locate temperature, moisture, or insect problems; and 3) aerating the grain to maintain uniform temperature and moisture conditions, prevent localized hot spot development, and to cool existing or developing hot spots. This NebGuide deals specifically with the aeration part of an overall management program for dry grain in storage.

Aeration systems should not be confused with the higher airflow system designed for natural air drying. Stored grain is aerated primarily to control grain temperature. Relatively low airflow rates, typically between 1/10 and 1/5 cubic feet of air per minute per bushel (cfm/bu), are adequate for this purpose. These airflow rates are not high enough to do a significant amount of drying. It is important that grain be stored at the proper moisture content and that the aeration system is managed to maintain favorable storage conditions.

Storable Grain Moisture Contents

The moisture content at which grain should be stored to maintain quality depends on the type of grain, the length of the storage period, and the temperature of the grain while in storage. Well designed and managed aeration systems can be used to either temporarily hold higher moisture grain at cool temperatures or to store dry grain for several years.

Recommended stored grain moisture contents for Nebraska are listed in *Table I*. These recommendations assume the grain is aerated to prevent heating. Reduce the recommended moisture contents by 1 percent when storing low quality grain. This includes immature grain, severely cracked and damaged grain, and grain subject to previous insect or mold activity.

Table I. Maximum recommended stored grain moisture contents for aerated grain.

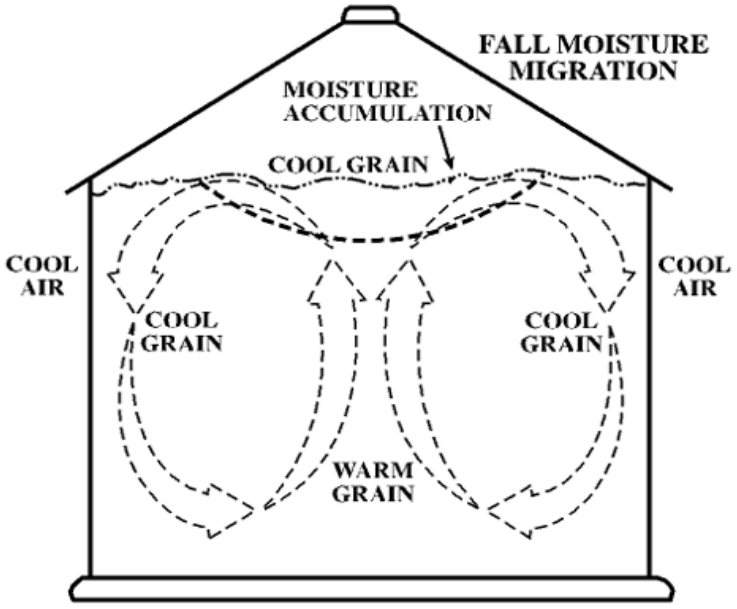
Storage Period	*Corn and Sorghum*	*Soybeans*	*Small Grain*
Marketed by June	15.5%	13%	--
Up to one year	14%	12%	13%
Over one year	13%	11%	13%

The moisture recommendations in *Table I* refer to the wettest grain in the bin, not the average moisture content. Hot spot development often starts in pockets of high moisture grain which can occur as the result of improper drying, condensation, bin roof or sidewall leaks, or moisture migration. Aeration can help disperse these moisture pockets and equalize moisture contents within the bin.

Moisture Migration

A common problem associated with longterm storage of dry grain is moisture movement within the grain mass, or moisture migration. Moisture migration is a result of convective air currents caused by temperature differences within the grain mass. This problem is especially severe when grain has not been properly cooled before winter storage and air currents move moisture to the top center area of the bin as shown in *Figure 1*.

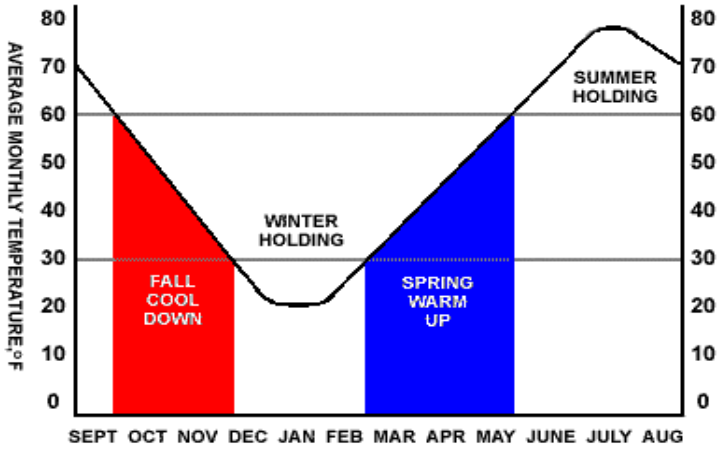
Figure 1. Air convective currents that cause moisture migration problems in bins of improperly cooled grain.



Normally, moisture migration problems do not become readily apparent before spring when air temperatures begin to warm. The first indication of trouble is usually damp or tacky feeling kernels at the grain surface, followed by the formation of a crust. If this problem is discovered in time, the crust can be broken up and the aeration fan turned on to cool and dry the grain in the area of

Figure 2. Aeration periods appropriate to the average monthly temperatures in Nebraska.

moisture accumulation. Better yet, the fan should be operated on a timely basis throughout the year to maintain uniform grain temperatures and prevent moisture migration.



Aeration Management Schedule

The primary objectives of aeration are to keep the grain at a seasonally cool temperature and to maintain uniform grain mass temperatures preferably with no more than a 10° F difference in temperature from one part of the bin to another. These objectives can generally be achieved by keeping grain temperatures within 10°F to 20°F of the average ambient temperatures shown in *Figure 2*. A different fan operation schedule is needed for each of the four seasonal aeration periods.

Before discussing seasonal aeration recommendations in detail, it is important to understand how cooling occurs in a bin (the same principles apply for warming grain). A cooling zone is established and moved through the grain in the same direction as the airflow. The rate at which the cooling zone moves is directly related to the total volume of air moved through the grain a function of both the airflow rate (cfm/bu) and the number of hours the fan is operated. When the fan is turned off, movement of the cooling zone stops. Cooling zone movement resumes when the fan is turned back on.

When changing grain temperatures during the fall and spring, run the fan continuously until the cooling or warming zone has been moved completely through the grain. The information in *Table II* can be used to estimate the time required to complete a temperature change for grain stored in either a bin equipped for natural air drying or in a conventional storage facility. The amount of time actually required to change the temperature of a specific bin of grain can only be determined by monitoring cooling or warming zone progress. Monitoring is especially important in facilities where airflow distribution is nonuniform due to such factors as duct placement or fines concentrations.

There are a number of fan operation schedules that can be used to maintain stored grain quality. Following the management procedure outlined below will help assure that basic aeration requirements are met. Adapt it as necessary to meet your individual needs and conditions.

FALL

- Move at least one (preferably two) cooling zone(s) through the grain to remove field or dryer heat and help equalize moisture contents.
- Thereafter, move one cooling zone per month through the grain until it is cooled to between 30°F and 40°F.
- Check the grain temperature and condition every two weeks and as needed to monitor cooling zone progress.

The initial cooling is important. Do not skimp on fan operation. Turn the fans on as soon as grain covers the perforated floor or aeration ducts, and operate them continuously until all the grain has been cooled to the prevailing outside temperature. Since cooling is the primary concern, especially if the grain has

come from a dryer, do not turn the fans off during rainy or humid weather. Failing to get the grain properly cooled can cause more problems than the small amount of rewetting that occurs from running the fan on a humid day.

In Nebraska, average air temperatures drop at the rate of 2.5°F to 3°F per week during the fall. Cooling the grain once per month will keep grain temperatures within 10°F of the outside air temperature. Continuous fan operation is recommended to make these monthly temperature changes, but a carefully managed intermittent fan operation schedule can be used to move a cooling zone through the grain; however, intermittent fan operation may make it more difficult to keep track of the location of the cooling zone.

Whichever program is followed, keep grain temperatures within 10°F of the average outside air temperatures to minimize moisture migration and condensation problems.

Table II. Relationship between airflow rate and the approximate time required to move a cooling or warming zone through grain.

System Type	*Airflow Rate, cfm/bu*	*Cooling or Warming Time, hours*
Natural Air Drying	1	12-15
	3/4	16-20
Aeration	1/5	60-75
	1/10	120-150

WINTER

- Check the grain temperature and condition at least once a month.
- Aerate as needed to maintain grain temperatures between 30°F and 40°F.

During the winter it is no longer necessary to think in terms of moving cooling zones through the grain. The aeration system needs to be operated only on a maintenance schedule to control localized temperature increases. In fact, it may not be necessary to run the fan at all during the winter if the grain remains dry and in good condition. One aeration strategy is to operate the fan for a few hours as part of a bi-weekly or monthly grain checking program. This allows the operator to check the exhaust air for off-odors, an indication that the grain requires immediate attention.

Avoid operating the fan on very cold or very warm days. This is especially true on days when the air temperature is warmer than the grain temperature since fan operation can result in moisture condensing and possibly freezing on the grain. This condensation problem can be prevented by operating the fan only when air temperatures are the same or cooler than grain temperatures.

Freezing grain is not generally recommended because of the increased likelihood of condensation problems if the grain is not properly warmed in the spring. However, freezing the grain becomes a secondary concern if the grain begins to heat or go out of condition. If a problem occurs, operate the fan continuously, regardless of weather conditions, until it is corrected.

SPRING

- If the grain is not frozen and will be marketed or fed by June, aerate only as needed to control "hot

spot" and heating problems.
- If the grain is frozen, move a warming zone completely through the grain as soon as temperatures are above freezing.
- If the grain is to be held until July or August, move one warming zone per month through the grain until it is uniformly warmed to 60°F.
- Check the grain temperature and condition every two weeks and as needed to monitor warming zone progress.

It would seem to make little sense to go to the trouble of warming grain in the spring after cooling it down in the fall. In fact, there is little reason to warm the grain if it is to be marketed or fed by summer. One exception is that frozen grain should always be thawed before being handled in warm weather. Operate aeration fans continuously when thawing frozen grain to prevent freezing of condensed moisture on the grain.

Fans should also be operated continuously when warming grain to 60°F in preparation for summer storage. This temperature is cool enough to slow insect activity, yet warm enough to minimize condensation if the aeration fans need to be operated to control localized heating in the bin. Since average outside temperatures again change at the rate of 2.5°F to 3°F per week, one warming zone per month should be sufficient to maintain uniform grain temperatures.

SUMMER

- Check the grain at least once every two weeks to monitor temperature, moisture, and insect activity.
- Consider operating the fan one night per week through June to help maintain grain temperatures at 60°F.
- Otherwise, cover fan openings during June, July and early August.

Grain checking is very important during the summer because grain is being held at higher temperatures and aeration conditions are less favorable than for the rest of the year. Grain temperatures need to be checked and recorded on a regular basis. Without temperature records, it is difficult to tell whether high grain temperatures are caused by normally occurring outside temperatures or by heating due to mold activity. Insect activity is also at a peak during the summer and frequent checking is required if infestations are to be controlled before they develop into major problems.

Not all of the grain going into the summer at 60°F will remain at that temperature. The grain along the bin sidewall and the grain surface will be gradually warmed over the course of the summer. Operating the fan on cool nights helps to bring these temperatures back down. However, aeration is normally beneficial for only part of the summer because of high temperatures during July and August. Do not operate the fan during these months unless a problem situation develops.

Although aeration fans are not normally operated during this period, there are still some temperature control measures that can be effective. One is to ventilate the roof space to prevent high summertime temperature buildups. This can be accomplished to varying degrees by using equipment ranging from gravity vents to exhaust fans.

Perhaps more important than moving air through the roof space is to keep air from moving down through the grain. The best way to prevent this is to cover the aeration fan openings when the fans are not in operation. If the fans are not covered, the cooler air in the grain will move out of the bin through the fan and draw warmer air down into the grain. This reverse chimney effect can gradually warm all of

the grain in the bin up to 70°F to 80°F. These temperatures increase the risk of mold problems and provide a favorable environment for insect activity.

Moisture Changes During Aeration

Aeration systems are not designed to dry grain; however, some moisture is uniformly removed from grain when it is cooled. The amount of moisture removed depends on both the temperature of the warm grain and the temperature of the cooling air. Cooling grain taken directly from a high speed dryer can remove as much as 0.25 points of moisture for every 10°F the grain is cooled. A lesser amount of moisture is removed when stored grain is cooled about 0.15 points of moisture for every 10°F of cooling. For example, moisture contents would be reduced approximately 0.5 percent if grain were cooled from 65°F to 35°F during the fall. This relatively small amount of moisture is removed rapidly, requiring only the time needed to move a cooling zone through the grain (*Table II*).

A more commonly expressed concern is the amount of rewetting that can occur during an aeration cycle. This is normally not a problem if fan operation is limited to the relatively short period of time required to move a cooling or warming zone through the grain. In most cases, the effects of operating the fan during humid conditions are more than compensated for by the number of hours the fan operates under more favorable conditions.

Aeration Controllers

When using an aeration controller, the principles for aeration of stored grain are the same as described above. The aeration controller should be programmed to follow the same guidelines. The control has the advantage of being able to automatically select the best temperature and humidity air for controlling the grain temperatures, and, to a lesser extent, moisture content. When using an automated controller one should not assume that the automatic system will take care of all of the problems. It is still necessary to regularly check the grain for detection of pockets of wet grain, rain or snow blowing into the bin, condensation, crusting, etc. This is also a check to make sure the controller is properly programmed and is operating correctly. If there is a problem, early detection is critical.

Summary

Maintaining proper grain temperature is important for both short-and-long term storage. Aeration is the most economical method of controlling grain temperature; however, aeration system capacities are seldom adequate to handle severe heating or moisture problems. Thus, a good aeration management program should be followed to both prevent storage conditions that favor mold and insect activity as well as react to problems that arise. Good managers further increase their chances for success by storing only clean, dry, high quality grain, and by complementing aeration management with a comprehensive grain monitoring program.

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