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Colorado State University Cooperative Extension

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Managing stored grain

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Quick Facts

By keeping grain temperature within 10° F of average outside air temperatures, air currents and moisture migration within the bin will be minimum.

Aeration should be continuous until the bin temperature change is complete.

Foreign material, fines, mold or insect infestation may cause unequal air movement through grain increasing both aeration costs and stored grain losses.

Aeration with known air flow rates (cfm/bu) will aid bin temperature management techniques.

Storage of grain on the farm has significantly increased mainly due to government programs and projected seasonal price increases above storage costs. Storage bins most commonly constructed in the past decade range from 5,000 to 45,000 bushel capacity. Little aeration is needed for bins holding less than 1,000 bushels of grain. Bins larger than 1,000 bushel capacity require greater management, such as periodic monitoring and regulating of grain temperature and moisture conditions to insure the quality of grain during storage.

Excessive grain moisture usually causes moldy grain and provides conditions for insect attack that seriously decreases the value of stored grain. Important factors affecting grain quality during storage include the type of grain, beginning temperature and moisture, bin size, rate, time and method of grain ventilation and length of storage.

Safe Storage Moisture

The predominant grains stored in Colorado are corn and wheat, while crops stored in lesser amounts include grain sorghum, barley, oats, sunflowers, soybeans and rye. Maximum percent moisture levels for safe storage of these grains are shown in Table 1. For poor quality grain, the recommended maximum moisture levels should be 1% below that shown in the Table. Poor quality includes grain produced in hailed fields or droughty conditions and grain containing a high percentage of broken and cracked kernels due to improper combine adjustment.

Table 1: Moisture content for safe storage of aerated grain.

Grain type	Maximum safe moisture content
Shelled corn and sorghum to be sold as #2 grain by spring.	15.5%
To be stored up to one year.	14.0%
To be stored more than one year.	13.0%
Soybeans	
To be sold by spring.	14.0%
To be stored up to one year.	12.0%
Small grain (wheat, oats, barley, rye)	13.0%
Sunflowers	
To be stored up to six months.	10.0%
To be stored up to one year.	8.0%

Taken from Agricultural Engineers Digest. 1980. **Managing Dry Grain in Storage.** *Iowa State University. Ames, IA 50011.*

Grain Temperature and Moisture Migration

More grain is lost because of poor grain temperature management than for any other reason. Poor temperature management can subsequently affect moisture, which in turn enhances problems with insects and molds.

Initial temperatures for grain storage vary because of seasonal harvest periods. For example, wheat harvested in mid-summer is stored at 80° to 90° F while corn or sorghum harvested in

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late fall goes into storage with temperatures of 30° to 60° F.

Grain typically has good insulation properties. As storage extends over several seasons, the center mass of grain remains about the same temperature as it was at the time of storage. Outdoor ambient (average) temperatures fluctuate with the season and thus the outer layer of grain changes in temperature causing slow movement of both air and moisture. Air and moisture movement in stored grain will occur when grain temperature and the outside ambient temperature differ. The direction and speed of this movement depends on the temperature gradient between grain and outdoor temperatures (Figure 1).

This natural circulation occurs when heavy cool air drains down through the grain near the outer edge of the bin and moves upward after warming in the center. As air temperatures rise, air becomes lighter, its moisture holding capacity increases and it moves upward through the grain, collecting additional moisture. As the warmed air reaches cooled layers of grain, excess moisture condenses to increase grain moisture. This process is called moisture migration. Obviously, grain near the sunny side of the storage bin is warmer than that on the shady side, creating additional migratory currents.

Regardless of the time of year, the best rule is to maintain grain temperatures within 10° F of the outside ambient temperatures. Minimum grain temperatures should be 30° to 40° F. It also should be realized that crusting and potential insect and mold conditions can occur when the grain moisture level is at or below maximum storage recommendations at the time the storage unit is filled.

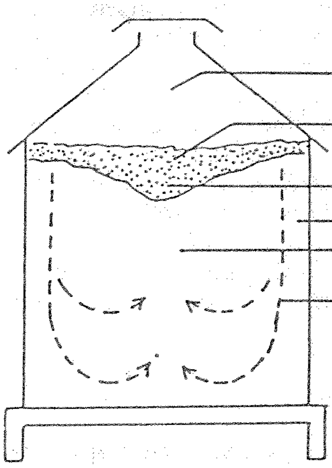


Figure 1: Winter grain conditions and air-moisture migration.

Frozen Grain

The practice of cooling stored grain below freezing is not encouraged. There is no advantage to freeze stored grain, while disadvantages include condensation and aeration problems when the grain warms in the spring. During spring aeration, condensate near frozen chunks of grain may refreeze thus blocking aeration in that zone. This blockage causes air channeling around the high moisture zone promoting mold formation.

Clean Grain

Store only clean dry grain. Successful aeration for temperature and moisture control depends upon consistent, even airflow throughout the storage unit. Cracked grain, foreign material and fines create problems in stored grain. Broken or cracked kernels damaged during harvest are more subject to spoilage than sound kernels. Foreign material such as broken cobs, stalk segments, weed seeds and fine material accumulate in either the center of the bin or in pockets near the edge. Airflow from aeration fans is channeled around pockets of fines and foreign material resulting in minimum cooling and moisture removal, which may cause spoiled grain in zones of poor aeration.

Management of Fines in Storage

When bins are loaded from the center, fine material including broken kernels tend to remain in the center, while sound kernels and larger particles move outward. Several techniques may be used to help prevent storage problems caused by fines.

Grain spreaders sometimes aid in distributing large amounts of foreign material, lessening the problem. Grain spreaders should, however, be used with caution as excessive grain packing may occur increasing airflow resistance. Sometimes grain can be cleaned, taking out the problem material. Properly adjusted combines will reduce the amount of cracked grain, fines and foreign material in stored grain.

Another possibility of storage improvement is frequent withdrawal of grain from the center core of the unit to remove the accumulated fines. When filling, grain flow should be directed to the center of the bin. Remove grain at regular intervals during filling to eliminate the accumulation of fines in the center of the unit (Figure 2).

Successful removal of fines and foreign material or the uniform distribution of this material will allow uniform airflow patterns within the bin.

Airflow Rates

The needed airflow rates through grain depend upon the specific storage unit and management techniques used. Systems designed only for temperature control may require airflow rates as low as 1/20 cfm/bu. High airflow rates require high capacity fans, use more energy and have high equipment and depreciation costs. The most common airflow rates are designed to provide between one-third and one cfm/bu providing some drying capabilities in addition to rapid cooling.

Aeration rates for a particular bin depend on the bin type, air distribution system, desired grain moisture content and management practices to include close monitoring of changing grain conditions. Grain type and storage design affect static pressure dictating fan size. For example, airflow resistance from 1/2 cfm/bu through 20 feet depth of corn results in static pressure of 2.6 inches of water column while fans moving air through wheat must overcome 5.9 inches of static pressure from the same bin size and airflow rate. By increasing the depth of grain to 25 feet, static pressure increases to 3.09 and 9.13 inches of water column.

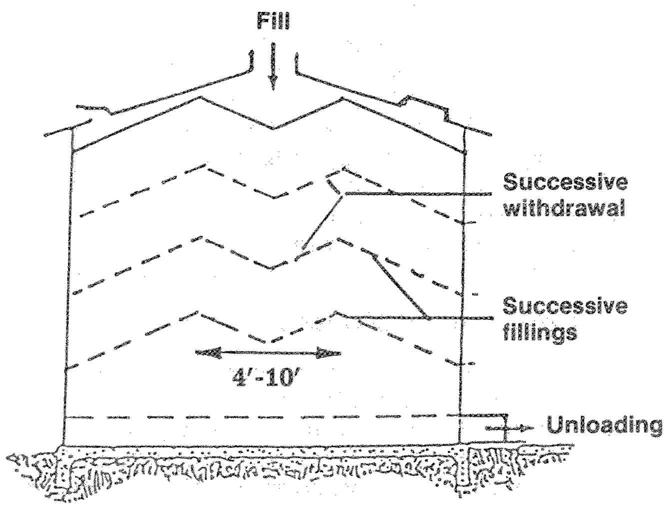


Figure 2: Withdrawals during filling to remove fines.

Fan Operation Time

Fan operation time required for each cooling or warming cycle depends on the aeration rates and the climate. To keep storage problems to a minimum, grain temperatures within the bin should be as uniform as possible. When outside air temperatures are 10° F or more different than bin temperatures, aeration is recommended to reduce moisture migration.

Fall—The initial cool-down after harvest is very important in removing heat and equalizing moisture levels. After this first conditioning, at least one cooling zone should be moved through the grain until it is cooled to a minimum of 35° to 40° F. The grain should be checked every two weeks for changes in temperature and moisture.

Winter—Check grain temperature and condition every month and aerate as needed to maintain grain temperatures between 35° to 40° F. If the fan is turned on to check for odors or heat, it should be operated when outdoor temperatures are near that of the grain, preventing moisture condensation.

Spring—If the grain is to be fed or marketed in the spring, aerate only as needed to control hot spots and heating problems. If the grain is frozen or if storage will extend to the summer months, a fan should be run to warm the grain when outside ambient temperatures are more than 10° F warmer than grain temperatures. This would occur about once per month during the period March through June. Fans should be operated continuously when thawing frozen grain to prevent refreezing of condensed moisture on the grain.

Grain temperatures should be increased at intervals until 60° F is maintained for summer storage. Sixty degree temperatures will help reduce insect activity during the summer.

Summer—Check the grain every two weeks to monitor temperature, moisture and insect activity. Fan operation at night if needed during the summer should be considered. Nighttime fan operation during the summer will keep grain temperature cooler and reduce additional grain drying as compared to aeration during the day. When the fan is not in operation, all openings should be covered during June, July and August to prevent drafts.

It is important to keep detailed temperature and general grain condition records. Without these records, it may be difficult to separate normal summertime temperature rises from an increase in temperature due to insect activity and mold.

Airflow Direction and Observation Techniques

Positive pressure systems have an advantage when detecting hot spots, insect activity, mold and moisture condensation on the grain surface, since the observer enters the bin from the top and can easily test air temperature. The top of the grain is last to cool or warm and is easiest to visually detect problems.

To check positive pressure systems, feel the grain and all surfaces for moisture accumulation, crusting, sticky or frozen grain and smell for musty odors. The use of metal rods and probes are beneficial in shallow bins. Electronic temperature sensing cables are helpful in large, deep storage structures. Temperature-sensing cables accurately trace cooling or warming fronts and aid in detection of hot spots. High or low airflow rates work equally well, depending on the system.

Negative airflow or suction systems move grain-tempered air down through the fan. Temperature and moisture deviations must be observed in the fan exhaust zone. With this system, the last grain to cool is next to the bin floor. High airflow rates may draw fine particles from the grain that may lodge on the outside of the air duct, creating poor aeration zones. Negative airflow system airflow rates should be about 1/10 cfm/bu.

Either system is satisfactory as long as all sound grain management criteria are considered (Figure 3).

Proper Ventilation

When using either positive or negative systems, it is necessary to provide adequate venting. Adequate venting provides the means for excessive moisture to escape and prevent structural damage. Closed vents and doors on suction sys tems during fan operation most likely will cause the roof to collapse. Likewise, in a positive flow system, fan operation in a closed bin will probably cause bulging and related structural damage.

Aeration Time

To estimate the time required to completely change the temperature of a specific grain bin, refer to Table 2.

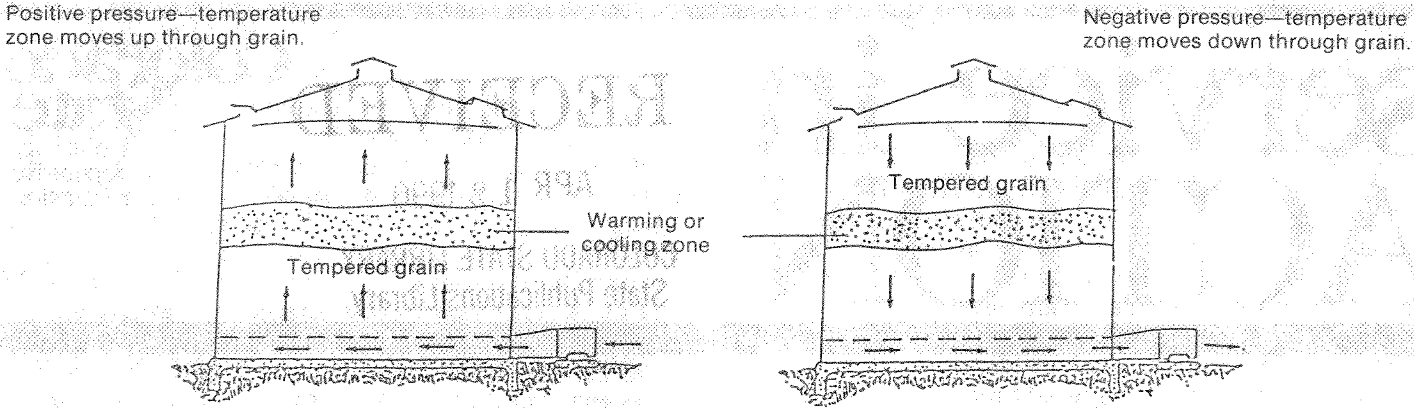


Figure 3: Air flow direction showing positive and negative pressure.

Table 2: Approximate cooling or warming times to move a complete cycle-through grain for a 10° to 15° F temperature change.

System	Airflow rate cfm/bu	Cooling or warming time hours
Aeration	1/10	120-150
	1/4	48-60
	1/3	36-45
	1/2	24-30
	3/4	16-20
Natural air drying	1	12-15
	1-1/4	10-12
	1-1/2	8-10

The actual time required for a complete temperature change may vary because of uneven or reduced airflow caused by climatic conditions or grain quality and can only be determined by monitoring the cooling or warming zone.

Variations in temperature change can be detected indicating when the cooling or warming cycle is complete by placing an adequate thermometer 6 to 12 inches into the grain in various locations.

Moisture Removal

The amount of moisture removed, or added, from aeration depends on the temperature of the grain, the temperature of the cooling or warming air and the relative humidity. The change in moisture is normally not a concern if fan operation is limited to the relative short period of time required to move cooling or warming zones through grain.

Grain Storage Mathematics

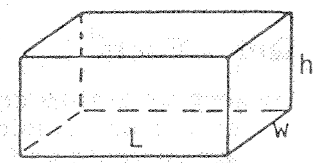
Grain storage losses may be reduced by following recommended air flow guidelines. Performance data provided by the system manufacturer will give an estimate of cfm (cubic feet of air per minute) delivered during operation for a given fan model delivering air through a specific type and depth of grain.

When calculating cfm/bu, the number of bushels in the structure must be known. The amount of grain stored may be calculated by using the following formulae, either singly or in combinations, to estimate total bushels stored.

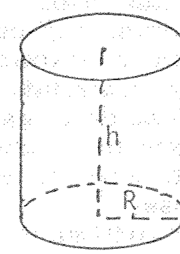
Grain storage units may be rectangular, cylindrical, cone shaped or trapezoidal in shape.

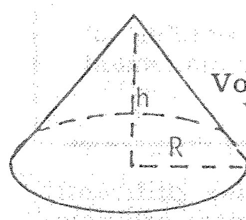
To calculate:

Volume of a rectangle
$V = WLh$



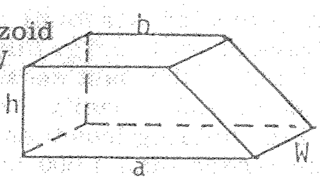
Volume of a cylinder
$V = \pi R^2 h$





Volume of a cone
$V = 1/3\, \pi R^2 h$

Volume of a trapezoid
$V = 1/2\,(a+b)hW$



V = Volume
L = Length
W = Width
h = Height
R = Radius
π = 3.1416

$$\frac{\text{total air input}}{\text{stored bushels}} = \text{cfm/bu}$$

1 bushel = 1.244 cubic feet
1 cubic foot = .8 bushel

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