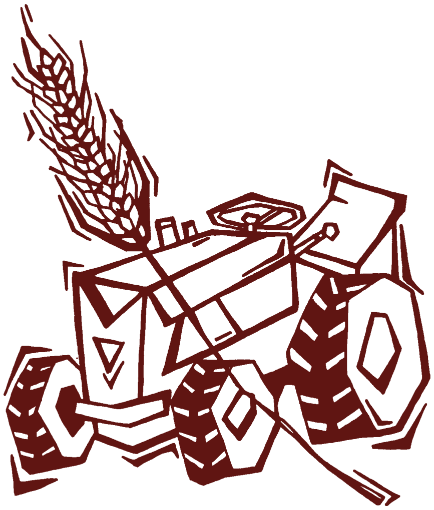


PRODUCTION

Managing Stored Grain no. 0.117

by R.L. Croissant [1]

Quick Facts...

Keep grain temperature within 10 degrees F of average outside air temperatures to minimize air currents and moisture migration within the bin.

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.

Colorado State University Cooperative Extension

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. Larger bins require greater management, such as periodic monitoring and regulating of grain temperature and moisture conditions to ensure 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

Corn and wheat are the grains most often stored in Colorado. Other crops include grain sorghum, barley, oats, sunflowers, soybeans and rye. Maximum percent moisture levels for safe storage are shown in Table 1.

For poor quality grain, the recommended maximum moisture levels should be 1 percent 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.

Grain Temperature and Moisture Migration

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

Initial temperatures for grain storage vary because of seasonal harvest periods. Wheat harvested in midsummer is stored at 80 to 90 degrees F. Corn or sorghum harvested in late fall goes into storage at 30 to 60 degrees.

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. As outdoor temperatures fluctuate with the season, the outer layer of grain changes in temperature. This causes slow movement of both air and moisture. 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,

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 1 year	14.0%
To be stored more than 1 year	13.0%
Soybeans	
To be sold by spring	14.0%
To be stored up to 1 year	12.0%
Small grain (wheat, oats, barley, rye)	13.0%
Sunflowers	
To be stored up to 6 months	10.0%
To be stored up to 1 year	8.0%

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

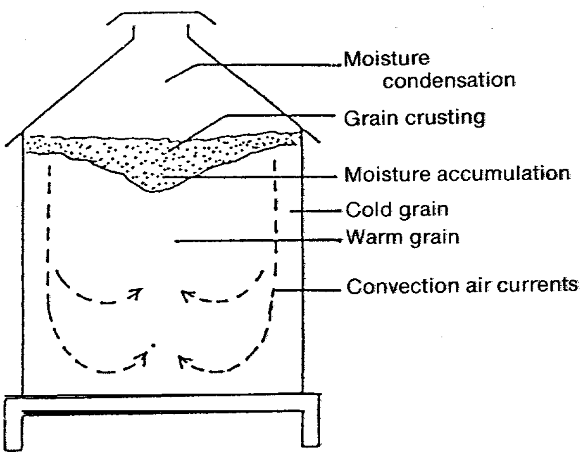


Figure 1. Winter grain conditions and air-moisture migration.

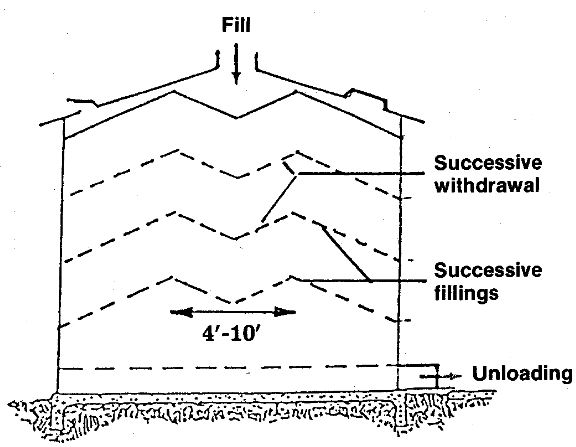


Figure 2. Withdrawals during filling to remove fines.

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 keep grain temperatures within 10 degrees of the outside temperatures. Minimum grain temperatures should be 30 to 40 degrees. 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.

Frozen Grain

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

Clean Grain

Store only clean, dry grain. Successful aeration for temperature and moisture control depends on consistent, even air flow 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 (broken cobs, stalk segments, weed seeds and fine material) accumulate in the center of the bin or in pockets near the edge. Airflow from aeration fans is channeled around these pockets, resulting in minimum cooling and moisture removal. This 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, tends to remain in the center. Sound kernels and larger particles move outward. Several techniques may help prevent storage problems caused by fines. Successful removal of fines and foreign material or the uniform distribution of this material will allow uniform airflow patterns within the bin.

Grain spreaders sometimes help distribute large amounts of foreign material, lessening the problem. However, use them with caution. Excessive grain packing may occur, increasing airflow resistance. Sometimes grain can be cleaned, taking out the problem material. Properly adjusted combines reduce the amount of cracked grain, fines and foreign material in stored grain.

Another way to improve storage is frequent withdrawal of grain from the center core of the unit to remove the accumulated fines. When filling, direct grain flow 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 required airflow rates through grain depend on 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 (cubic feet of air per minute per bushel). High airflow rates require high capacity fans, use more

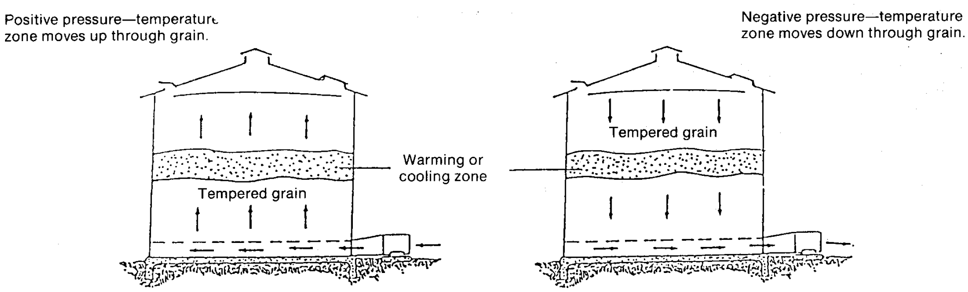
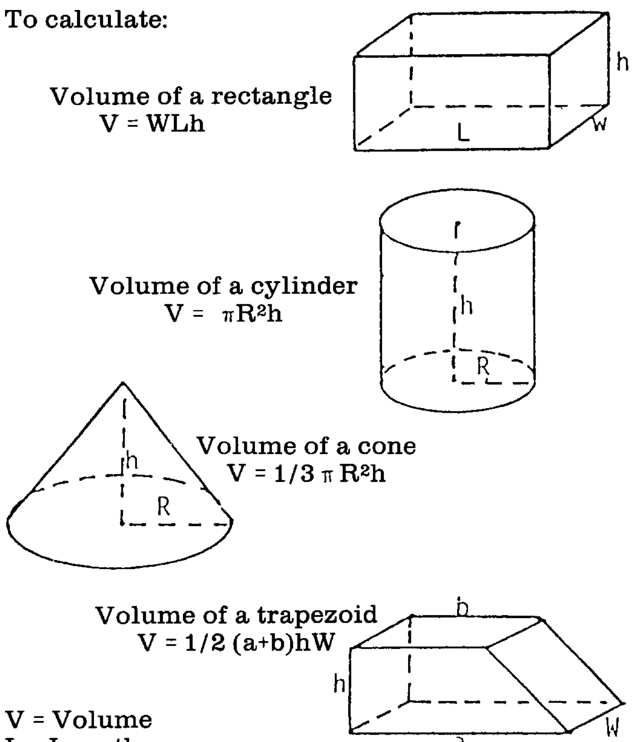


Figure 3. Air flow showing positive and negative pressure.

To calculate:



V = Volume
L = Length
W = Width
h = Height
R = Radius
= 3.1416
1 bushel = 1.244 cubic feet
1 cubic foot = .8 bushel

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

Figure 4. Volume calculations for grain storage units.

energy and have high equipment and depreciation costs. The most common airflow rates are designed to provide between 1/3 and 1 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, including close monitoring of changing 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. Fans moving air through wheat must overcome 5.9 inches of static pressure from the same bin size and airflow rate. A 25-foot depth of grain increases static pressure to 3.09 and 9.13 inches, respectively.

Fan Operation Time

Fan operation time required for each cooling or warming cycle depends on the aeration rates and the climate. To minimize storage problems, keep grain temperatures within the bin as uniform as possible. When outside air temperatures differ by 10 degrees or more from bin temperatures, aerate to reduce moisture migration.

Fall: The initial cool-down after harvest is important to remove heat and equalize 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 degrees. Check the grain 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 and 40 degrees. 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 to prevent moisture condensation.

Spring: If the grain will 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 summer, run a fan to warm the grain when outside ambient temperatures are more than 10 degrees warmer than grain temperatures. This would occur about once a month from March through June. Operate fans continuously when thawing frozen grain to prevent refreezing of condensed moisture on the grain. Increase grain temperatures at intervals until 60 degrees is maintained for summer storage. This temperature will help reduce insect activity during the summer.

Summer: Check the grain every two weeks to monitor temperature, moisture and insect activity. Run a fan at night if needed during the summer. This will keep grain cooler and reduce additional grain drying, compared to daytime aeration. When the fan is not in operation, cover all openings during June, July and August to prevent drafts.

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.

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

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

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, because the observer enters the bin from the top and can easily test air temperature. The top is last to cool or warm and is easiest to visually inspect for problems.

To check positive pressure systems, feel the grain and all surfaces for moisture accumulation, crusting, sticky or frozen grain. Smell for musty odors. 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 detecting 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 systems 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 grain bin, refer to Table 2. The actual time required may vary because of uneven or reduced airflow caused by climatic conditions or grain quality and can be determined only 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 estimate cfm delivered during operation for a given fan model delivering air through a specific type and depth of grain.

Grain storage units may be rectangular, cylindrical, cone shaped or trapezoidal. When calculating cfm/bu, the number of bushels in the structure must be known. Calculate the amount of grain stored by using the formulas in Figure 4, either singly or in combinations, to estimate total bushels stored.

References

McKenzie, B.A., L. Van Fossen and H.J. Stockdale. 1980. Managing dry grain in storage*. Agricultural Engineers Digest, Iowa State University, Ames, IA 10 pp.*

Hellerang, K.J. 1983. Natural air flow temperature crop drying. *Extension Bulletin 35. Cooperative Extension Service, North Dakota State Univ., Fargo, ND 29 pp.*

Pierce, R. 1984. Aeration of stored grain*, Nebguide, 684-692. Cooperative Extension Service, University of Nebraska, Lincoln, NE*

[1]Colorado State University Cooperative Extension agronomist and professor (retired); soil and crop sciences. Reviewed by Gil Waibel, Cooperative Extension seed certification specialist.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture, Milan A. Rewerts, Director of Cooperative Extension, Colorado State University, Fort Collins, Colorado. Cooperative Extension programs are available to all without discrimination. No endorsement of products mentioned is intended nor is criticism implied of products not mentioned.