1994

G94-1199 Management to Maintain Stored Grain Quality

David D. Jones
University of Nebraska - Lincoln, david.jones@unl.edu

David P. Shelton
University of Nebraska - Lincoln, dshelton2@unl.edu

G94-1199-A

NebGuide

Published by Cooperative Extension, Institute of Agriculture and Natural Resources, University of Nebraska-Lincoln

Management to Maintain Stored Grain Quality

This NebGuide describes many of the management factors that influence the quality of stored grain.

David D. Jones, Biological Systems Engineer
David P. Shelton, Extension Agricultural Engineer

Grain quality will not improve during storage. At best, the initial quality can only be maintained. When stored grain goes out of condition, it is usually the cumulative result of several interrelated management factors that include: 1) harvesting, handling, and storage equipment; 2) initial condition of the grain; 3) grain moisture content; 4) grain temperature; 5) aeration system management; 6) insect and mold control; and 7) monitoring grain condition. An effective management program greatly enhances the likelihood of maintaining top quality grain.

Harvesting, Handling and Storage Equipment

Grain bin and equipment maintenance prior to and during harvest lays the foundation for ensuring that good quality grain goes into storage and that grain quality is preserved.

Harvesting Equipment

Remove all traces of old grain from combines, truck beds, grain carts, augers, and any other equipment used for harvesting, transporting, or handling grain. Even small amounts of moldy or insect-infested grain left in equipment can contaminate a bin of new grain.

Adjust combines according to the manufacturer's specifications to minimize grain damage and to maximize removal of fines and other foreign material. Most manufacturers have instructional materials and/or videotapes to demonstrate effective combine adjustment and performance.

Operate augers at full capacity to reduce wear and grain breakage. With variable incoming flow rates, reducing auger speed can keep the auger operating at full capacity. Another option is to add a hopper over the auger intake, keeping it full. Be sure all safety shields and intake grates are kept in place and in good working order.

Bins and Other System Components

Check the bin site, and remove any items or debris that would interfere with safe, unobstructed movement around the bin. Remove any spilled grain and mow the site to reduce the likelihood of insect or rodent infestation. If necessary, re-grade the site so water drains away from bin foundations.

Inspect bins and foundations for structural problems. Uneven foundation settlement can cause gaps at the bottom edge of the bin. This can result in grain spills and provide entry points for water, insects, and rodents. Gaps between the foundation and bin will allow air that normally would be forced through the grain to escape from the bin. Small gaps usually can be filled with a high-quality caulking compound. If deterioration is extensive, the mastic seal may need to be replaced. Be sure all anchor bolts are tight and undamaged.

Inspect the bin roof and sides, inside and out, for leaks, loose or sheared bolts, and rust or other corrosion. Check the roof vents and access hatch, and caulk any cracks at the roof line. Be sure the access ladder is complete and securely fastened to the bin. Repair or replace any deteriorated parts.

Wiring for fans and other electrical components should be inspected for corrosion and cracked, frayed, or broken insulation. Exposed wiring should be routed through waterproof, dust-tight conduit. Avoid kinking the conduit, and make sure all connections are secure.

Check fans, heaters, transitions, and ducts for corrosion, and remove any accumulated dust and dirt that will reduce the operating efficiency. Be sure all connections are tight and shields are in place.

Thoroughly clean the bins. Use brooms and vacuum cleaners to remove all old grain. **Do not put new grain on top of old grain,** as this is a potential source of mold and insect infestation of the new grain. Also clean bins not being used for storage to keep insects from migrating to other bins.

Although it is difficult to thoroughly clean under perforated floors, a grain vacuum can be used to remove much of the accumulated dust and fine material. Removing the fan allows access to the underside of the floor.

If long-term storage (over 10 months) is planned, consider treating the bin with an approved insecticide two to three weeks before new grain is added. Treat as many surfaces as possible, especially joints, seams, cracks, ledges, and corners. Spray surfaces to the point of runoff. Also treat outside the bin at the foundation and around doors, ducts, and fans. As with all pesticides, read and follow label directions during handling, mixing, application, and clean-up. Refer to publication *EC1534, Pest Management of Farm-Stored Grain*, for details and specific insecticide recommendations.

Initial Grain Condition

Good quality, clean, sound grain is much easier to maintain in storage than cracked and broken grain. Broken kernels will mold three to four times faster than whole kernels. Broken grain also is more susceptible to insect attack, since some insects feed only on broken or cracked kernels. It is critical that initial grain condition receives considerable attention.

In addition to careful combine adjustment and operation, moisture content is a key factor influencing grain damage during harvest. The least grain damage generally occurs at moisture contents of 18 to 20 percent. The amount of damage increases slightly for moisture contents below this range, but increases rapidly for moisture contents above this range. Also, frozen grain damages easily, and combining or handling should be avoided if possible.

Grain Cleaners

In addition to increased mold and insect activity, fines and broken or cracked kernels disrupt airflow distribution, contributing to storage problems. Typically this occurs in the center of the bin. The best solution is to use a grain cleaner to remove the fines before placing grain in storage. Typical grain cleaners are gravity screens, perforated augers, and rotary screens.

Gravity screens pass the grain over a screen during the handling process. Some are stand-alone units fed from an auger. Others are part of a permanent installation such as at the output of a bucket elevator.

Perforated augers have a section of auger housing with multiple, small holes. As the grain is conveyed over this section of the auger, the fines are separated. This type of cleaner has limited effectiveness when the auger is operated at full capacity. Unfortunately, operating the auger at less than full capacity results in increased grain damage.

Rotary screen cleaners use a rotating screen that tumbles and separates the fines and foreign material from the grain (*Figure 1*). These can be very effective if operated according to the manufacturer's recommendations.

Grain cleaner capacity typically ranges from 500 to 3,500 bushels per hour. These capacities are approximately equivalent to 4 and 10 inch augers, respectively. Capacity is influenced by grain moisture content, type of grain, slope of the cleaner screen, and the amount of fines and foreign material in the grain. Check with the cleaner manufacturer for specific operating guidelines and conditions.

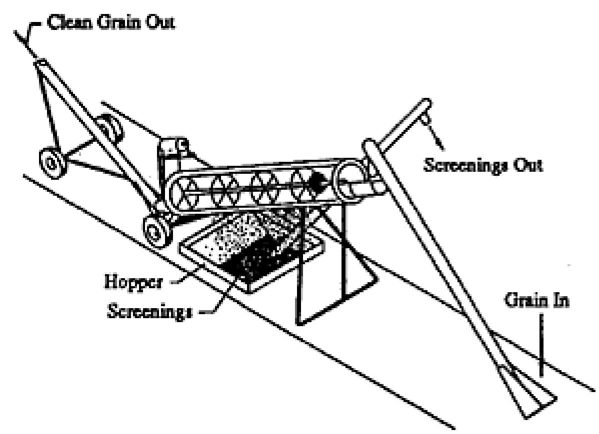

Figure 1. Rotary screen grain cleaner.

Cleaning is easier and more complete at low flow rates and with dry grain. Cleaning can be accomplished after drying if the grain is dried and stored in separate bins. If the grain is not cleaned prior to drying, be prepared to spend more time cleaning and maintaining the dryer. This maintenance is very important to maintain the capacity of the dryer and to reduce the possibility of fires.

Screenings are good livestock feed. However, if the screenings are wet, they should be fed within two days. Also, take care when feeding fines from damaged grain. Moldy, soft, partially rotten grain particles are screened with fines, and may contain toxins harmful to livestock.

Grain Spreaders

After filling, the grain surface in the bin should be level. Peaked areas increase airflow resistance. Peaking also makes it more difficult and dangerous to monitor grain condition.

A properly adjusted and operated grain spreader can leave the top surface of the grain level with the fine material more evenly distributed throughout the grain mass. This results in more uniform airflow resistance throughout the bin.

One problem with using a grain spreader is that the grain tends to be packed tighter in the bin. Although this might seem good since more grain can be stored in each bin, packing increases airflow resistance, and the depth of grain may need to be decreased accordingly. A stirring device can loosen the grain, but excess use can contribute to grain damage. If a grain spreader is not used when filling a bin with grain that includes excess fine material, periodically unload a volume of grain from the center of the bin, a practice known as "coring." The objective is to create a 5 to 10 foot diameter depression in the center of each successive layer (*Figure 2*). The grain that is removed can be mixed with other grain and put back into the bin.

This practice does not remove the fines, but repeated unloadings help redistribute many of the fines that normally would accumulate in the center of the bin. This creates areas of relatively clean grain that improve airflow through the center of the grain mass. After the final filling, the grain surface should be leveled.

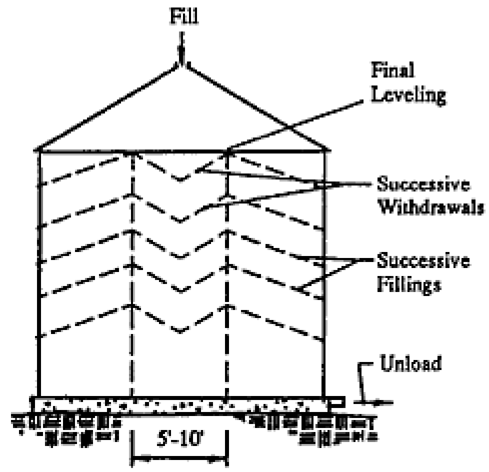

Figure 2. Coring a bin of grain to redistribute the fines and improve airflow distribution.

Moisture Content

If grain moisture content is too high, even the best aeration equipment and monitoring management will not keep the grain from spoiling -- it only delays the inevitable. Recommended moisture contents for stored grain are listed in *Table I*. These recommendations refer to the **wettest grain in the bin, *not* the average moisture content.**

These values should be reduced by one to two percentage points when storing lower quality grain such as immature or drought-stressed grain, severely cracked or damaged grain, and grain previously subjected to insects or molds. DO NOT exceed these moisture levels.

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

Storage Period	Corn and Sorghum	Soybeans	Small Grain*
Fed by early spring	18%	13%	13%
Fed or marketed by June	15.5%	13%	13%
Stored up to one year	14%	12%	13%
Stored longer than one year	13%	11%	13%
*Since small grains are harvested in the summer and held through warm weather, moisture contents should be less than those for corn and sorghum.			

If high temperature drying is used, operate the dryer at the lowest temperature possible. High temperatures reduce grain quality and make grain more susceptible to breakage and stress crack development. Excessive temperature also binds lysine in corn, making it unavailable to livestock.

High temperature drying should be discontinued when the grain moisture is about two percentage points above the desired final moisture content. The remaining moisture will be removed in the cooling process.

Cooling to ambient temperatures should take place over a four to six hour period. During this time the grain goes through a "steeping" process where moisture in the kernels redistributes and equalizes. Cooling the grain too rapidly can cause stress cracks; cooling too slowly encourages spoilage.

If grain is cooled in a storage bin, do not turn the fan off until all the grain has been cooled, regardless of weather conditions. Holding warm grain in a bin for even a few days is a needless risk.

Natural air drying is an excellent way to minimize grain damage. Natural air drying involves providing relatively high airflow rates, at least 1 cubic foot of air per minute per bushel of grain (cfm/bu), for extended periods (6 to 12 weeks), depending on the weather and initial grain condition. One critical aspect of natural air drying is that the initial drying front must be moved through the full depth of the grain bin as quickly as possible. To accomplish this, the fans must be operated continually. More information is available in NebGuide *G87-862*, *Natural Air Corn Drying*.

Drying costs and grain damage can be reduced if the grain is allowed to dry in the field. However, this must be weighed against the uncertainty of future weather conditions, and possible increased harvest losses.

Going into storage at the proper moisture content does not guarantee grain will remain at that moisture. Grain may be rewet as a result of bin roof or sidewall leaks. Moisture also can enter through downspouts from a bucket elevator or through hatches that have been left open.

Condensation also can cause localized increases in moisture content. Condensation, particularly on bin roofs and sidewalls, is common when warm grain (50°F or above) is cooled during cold weather (30°F or less), or when hot grain from a dryer is cooled in a storage bin. Minimize these condensation problems by cooling stored grain in stages during the fall; cooling hot grain from the dryer in a separate cooling bin before moving it to storage; and by providing adequate exhaust vents in the cooling bin.

Grain Temperature

Whether holding wet grain for a short period of time or storing dry grain for longer periods, it is important that grain temperature be controlled. Because both wet grain and molds respire and give off heat, aeration is needed to keep the grain cool and to slow mold growth. Aeration is the movement of relatively low volumes of air through stored grain. Airflow rates typically range from 0.1 to 0.75 cfm/bu. Properly aerated grain generally can be held safely about four times longer than non-aerated grain.

Aeration is needed to keep the grain mass at the desired temperature and to keep temperatures equalized, even if grain is dry and cool when placed in storage. Temperature differences within the grain mass create convection currents that can move and concentrate moisture in the top center of the bin. Problems caused by this moisture movement, or moisture migration, often become obvious in the spring when outside 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.

Moisture migration is more of a problem in peaked grain because the moisture is concentrated in a smaller volume of grain. Moisture also moves by vapor diffusion from warmer to cooler areas in the bin. If grain is not properly cooled for winter storage, there is a tendency for moisture to move to the cool grain along the bin sidewall, causing spoilage. Moisture movement problems can be minimized by keeping grain mass temperatures equalized and within 10° F of the average monthly outside air temperature.

It is especially critical to cool grain from warmer harvest or summer storage temperatures. Cooling the grain early in the fall, and keeping grain temperatures below 60° F as long as possible into the summer, will help minimize insect activity and increase the chances of getting through the summer without having to fumigate the grain.

Aeration System Management

The primary objectives of aeration are: 1) to keep the grain at a seasonally cool temperature, within 10°F of the average monthly ambient air temperature; and 2) to maintain a relatively uniform temperature within the grain mass -- preferably no more than a 10°F difference in temperature from one part of the bin to another.

Grain mass temperature needs to be controlled throughout the year: cooled in the fall; held at 35 to 40°F through the winter; warmed in the spring; and held at about 60°F through the summer.

A cooling or warming zone moves through the grain in the same direction as the airflow. The rate of movement depends on both the airflow rate (cfm/bu) and the hours of fan operation. For example, with an airflow of 0.1 cfm/bu it takes about a week to completely move a cooling or warming zone through the grain mass, whereas with an airflow of 0.75 cfm/bu, it takes approximately a day. When the fan is turned off, movement of the zone stops. Movement resumes when the fan is turned back on.

When changing grain temperatures, run the fan continuously until the cooling or warming zone has been moved completely through the grain. A commonly expressed concern is running aeration fans during rainy or humid weather. Rewetting of the grain is normally not a problem during the relatively short time it takes to move a cooling or warming zone through the grain. The effects of operating the fan during damp conditions usually are more than offset by the time the fan is operated under more favorable conditions.

A common question is whether the airflow should be upwards or downwards through the grain mass. From the standpoint of aeration system performance, the affect of airflow direction is negligible. However, from a management standpoint, upward airflow is preferred since the top of the grain mass will be the last area to change temperature when a cooling or warming zone is moved through the bin. This makes it easier to determine if the zone has moved completely through the grain.

Uniform airflow distribution is necessary for the most satisfactory temperature control. This requires clean grain, a level grain surface, and a well-designed aeration system, preferably with a fully perforated floor. Monitoring grain condition is especially important in facilities where these conditions are not present.

Refer to NebGuide *G84-692, Aeration of Stored Grain,* for detailed information on aeration system management.

Insect and Mold Control

Insects are generally not a problem in grain stored less than one year. However, if grain is to be stored for longer than a year, or if a bin has had an insect problem in the past, special precautions should be taken. Refer to publication *EC1534, Pest Management of Farm-Stored Grain*, for additional information and specific recommendations.

Left untreated, an insect infestation eventually will lead to other storage problems. Insects give off moisture that can cause grain moisture contents to increase enough to create a mold problem. Mold activity will in turn raise temperatures and result in an increased rate of insect reproduction. Greater numbers of insects create more moisture, and the cycle is repeated at an ever increasing rate.

Monitoring Grain Condition

Frequently monitor grain condition to verify that the desired temperature control is achieved. Regular examinations are essential if mold and insect activity are to be detected and controlled in a timely fashion. The method and frequency of checking will vary with time of year, initial grain condition, and aeration procedure. Generally, grain should be inspected at least once a month during the winter and every two weeks at other times of the year.

Extreme caution should be exercised when checking grain. Bridged grain is very dangerous, and collapse of the bridged area can result in suffocation. Always use a safety harness, lifeline, and grab rope, and have a second person outside the bin to assist in case of an emergency.

Monitoring grain condition is extremely important during the summer because grain is held at higher temperatures and aeration conditions are less favorable. Grain temperatures should be checked and recorded at least every two weeks. Without records, it is difficult to tell whether elevated temperatures are caused by normally occurring outside temperatures or by heating due to mold activity. Use a grain probe to locate any moisture pockets where molds will develop rapidly as temperatures warm. 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.

Failure to monitor grain condition throughout the entire storage period is a frequent mistake. A small area that starts to heat or otherwise "go out of condition" can quickly get out of control and spread within the bin. Think of the grain as being cash in the bin, and consider how frequently it would get checked if that were the case.

Some areas and conditions to check when monitoring grain quality include:

- Grain surface for condensation, crusting, wet areas, molds, and insects.
- Bin roof for condensation and leaks.
- Grain mass for non-uniform temperatures, high moisture pockets or layers, molds, and insects.
- Exhaust air for any off-odors.

If problems are detected, they need to be evaluated and corrected as soon as possible. This may include cooling with aeration, further drying, or fumigation for insect control.

Summary

It is critical to carefully manage stored grain to prevent deterioration and possible serious economic loss.

This should include:

- A well-designed and properly operated storage system with adequate aeration capacity.
- Storing only clean grain at the proper moisture content and temperature.
- Checking the grain condition regularly and correcting problems before they get out of hand.

File G1199 under: FARM BUILDINGS
D-9, Crop Storage and Drying
Issued April 1994; 7,500 printed.

Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Elbert C. Dickey, Director of Cooperative Extension, University of Nebraska, Institute of Agriculture and Natural Resources.