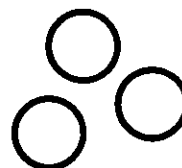


CROP DRYERATION AND IN-STORAGE COOLING



Kenneth J. Hellevang
Extension Agricultural Engineer

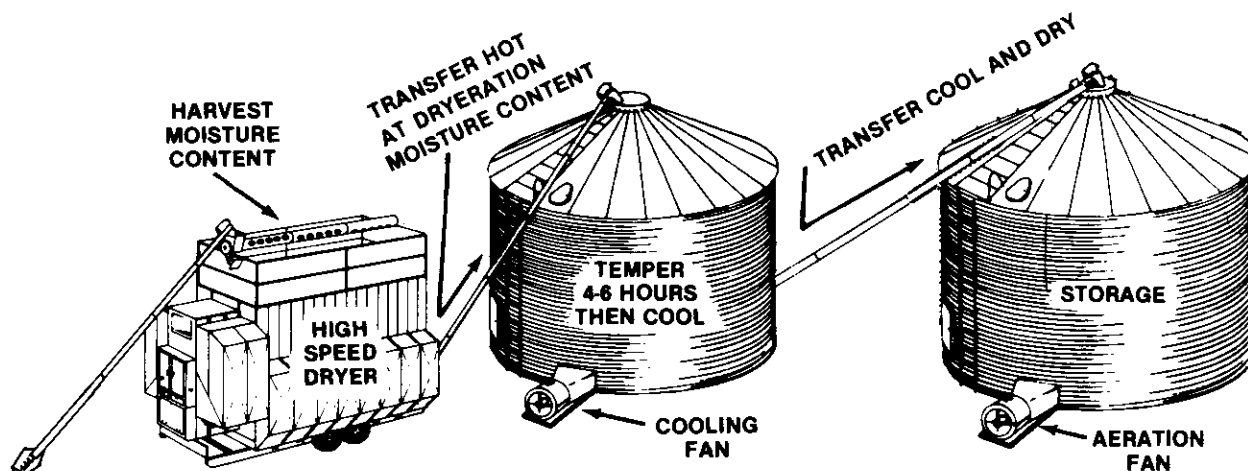


Figure 1. Schematic of dryeration system. Grain is dried in a high speed dryer to within 1-2% of safe storage moisture content. The hot grain is moved to the dryeration bin where it sits without airflow for 4-6 hours. After cooling, the grain is moved to storage.

Dyeration and in-storage cooling will increase the capacity and reduce the energy consumption of a crop dryer and may reduce the grain quality loss sometimes experienced during drying.

Dyeration (Figure 1) is a process where grain is removed from the dryer hot with a moisture content 1 or 2 percentage points above that desired for storage. The hot grain is placed in a dryeration bin where it is allowed to temper without airflow for at least four to six hours. After the first hot grain delivered to the bin has tempered, the cooling fan is turned on while additional hot grain is delivered to the bin. The grain is cooled and 1 to 2 percent moisture content removed by airflow before it is moved to final storage. Cooling is normally completed about six hours after the last hot grain is added if the cooling rate equals the filling rate.

storage in the dryer, then moved to storage where it is cooled.

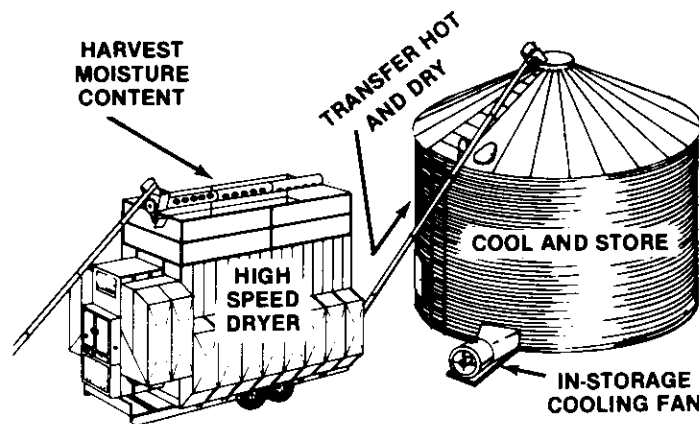


Figure 2. Schematic of in-storage cooling. Grain is dried in a high speed dryer to safe storage moisture content. The hot dry grain is then moved to storage where it is cooled.

In-storage cooling eliminates tempering (Figure 2). Grain is dried to the desired moisture content for



NDSU EXTENSION SERVICE

TEMPERING FOR DRYERATION

Immediately after high-speed high temperature drying, the inner portion of a kernel is wetter than the outer portion. During the tempering process the moisture equalizes throughout the kernel. Some moisture is then removed during the slow cooling process of dryeration. In contrast, little moisture is removed during rapid cooling.

The final moisture content of the grain after cooling must be estimated correctly to prevent spoilage or overdrying. The amount of moisture that can be removed by dryeration depends on the amount of heat removed from the kernel. Approximately 0.25 percent of moisture is removed for each 10°F reduction in kernel temperature. If the kernel temperature coming from a high-speed high temperature dryer is 100°F and the kernel is cooled to 70°F by dryeration, a 0.75 percent reduction in moisture content is expected. The expected moisture content reduction is 2 percent if the kernel temperature is cooled from 140°F to 60°F.

Kernel temperature can be determined by collecting kernels in a thermos bottle. Insert a thermometer among the kernels and read it as soon as the temperature stabilizes. Preheating the thermos bottle with grain coming from the dryer will reduce rapid cooling of the kernels and make the measurement more accurate.

Moisture testers in common use do not indicate accurate moisture contents on hot grain immediately after being discharged from a high-speed dryer. By rapidly cooling the sample with a small fan as illustrated in Figure 3, the kernel temperature can be lowered to the temperature recommended for the meter. A moisture correction is necessary because of the moisture variation in the kernels and because some moisture is removed during rapid cooling. The

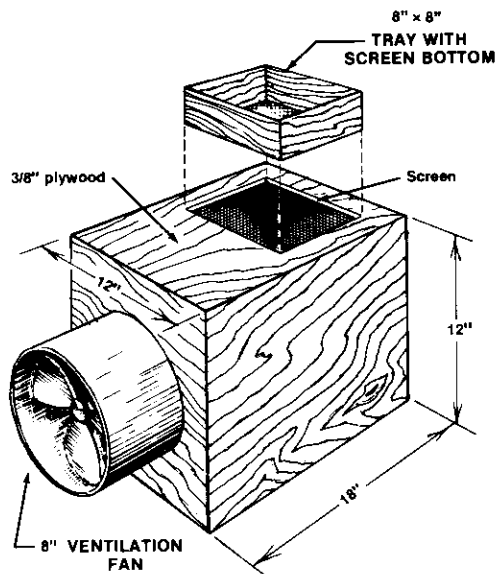


Figure 3. Diagram of one device for rapid cooling of hot grain for moisture determination. These are approximate dimensions. Any device to rapidly cool the grain is okay.

correction can be determined by using well-mixed duplicate samples. One is rapidly cooled before the moisture content is measured. This is the estimate. The other, sealed in a moisture-tight container, is allowed to cool for 24 hours before the moisture content is measured. This is the accurate measurement. It is also necessary to check the moisture content of the grain in storage to assure that the grain is at the desired moisture content.

DRYERATION AIRFLOW

The crop cooling rate should equal the filling rate of the dryeration bin. If grain is being dried and added to the dryeration bin at 300 bushels per hour, the airflow should cool the grain at the rate of 300 bushels per hour. A faster cooling rate will cool the grain before it has tempered. A slower rate may result in spoilage since the allowable storage time of hot, damp grain may be only a few days.

The required airflow rate is based on dryer capacity and on the weight of the crop. A minimum airflow rate of 12 cubic feet per minute (cfm) for each bushel per hour (bu/hr) of dryer capacity provides cooling capacity to keep up with the dryer when drying corn that weighs 56 pounds per bushel. A corn drying rate of 300 bu/hr would require an airflow rate of $300 \text{ bu/hr} \times 12 \text{ cfm/bu/hr} = 3600 \text{ cfm}$. Oil type sunflower at 32 pounds per bushel requires an airflow rate of 7 cfm/bu/hr. (Weight of sunflower ÷ weight of corn × 12 cfm/bu/hr = $32/56 \times 12 = 6.86 \text{ cfm/bu/hr}$). Wheat at 60 pounds per bushel requires an airflow rate of $60/56 \times 12 \text{ cfm/bu/hr} = 12.86$ or 13 cfm/bu/hr. Recommended airflow rates for some crops are listed in Table 1.

Table 1. Recommended Airflow Rates for Dryeration

| Crop | Weight (lb/bu.) | Recommended Dryeration Airflow Rate (cfm/bu/hr.) |
|-------------------------|-----------------|--|
| Barley | 48 | 10 |
| Corn | 56 | 12 |
| Durum | 60 | 13 |
| Edible Beans | 60 | 13 |
| Flaxseed | 56 | 12 |
| Millet | 50 | 11 |
| Oats | 32 | 7 |
| Rye | 56 | 12 |
| Sorghum | 56 | 12 |
| Soybean | 60 | 13 |
| Confectionary Sunflower | 24 | 5 |
| Oil Sunflower | 32 | 7 |
| HRS Wheat | 60 | 13 |

Size the cooling fan to deliver the required airflow when the bin is full. It is unrealistic to perfectly match the cooling rate with the drying rate. Cooling proceeds faster at the shallower depths than at the deeper depths because of the higher airflow rate. Fan starting and operating times can be varied based on experience to make sure that all hot grain goes through at least a four-hour tempering period before it is cooled.

The capacity of a high-temperature high-speed dryer may increase 50 percent or more by using dryeration. The drying capacity is increased because cooling is not done in the dryer, the grain is not completely dried and another heater for drying can be added to what was previously the cooling section of the dryer. Plan for the increased drying capacity when selecting the airflow and fan required for dryeration.

Air is moved upward in a dryeration bin, so the first grain delivered to the bin is the first grain cooled. If the air was pulled down, the cooled grain would be reheated each time hot grain was added. Also, condensation on the grain would be likely if warm moist air from the hot grain came in contact with cooled grain. Spoilage is a concern if the cooling air is pulled down through the grain.

Air in the bin is warm and damp during dryeration. Condensation will form when this warm, damp air comes in contact with the cooler bin wall or roof. More condensation will occur when there is a large difference between grain temperature and outdoor temperature. To reduce the roof condensation, provide at least 1 square foot of opening in the roof for each 1000 cfm of airflow. Adding fans and insulation may help but will not eliminate condensation. Move the grain to another bin for storage. This will mix the grain near the bin wall and near the top that has been wetted by condensation with dry grain in the rest of the bin. Spoilage is likely near the bin wall if the grain is not moved.

A fully perforated floor is recommended for dryeration. Ducts or partial floors may be adequate, but uniform airflow is not achieved. Since airflow takes the path of least resistance which is normally upward, more air will go through the grain above the ducts than between the ducts. Provide at least 1 square foot of duct cross-sectional area for each 1500 cfm of airflow in ducts and underfloor areas. Provide at least 1 square foot of perforated surface area for each 25 cfm. Select a fan that will deliver the required airflow at the expected static pressure.

Example: Select equipment for dryeration of oil type sunflower being dried at 500 bushels per hour and placed in a 5000-bushel 21-foot diameter bin.

1. Airflow = 500 bu/hr \times 7 cfm/bu/hr = 3500 cfm
2. Minimum duct area = 3500 cfm \div 1500 cfm/ft² = 2.33 ft²

3. Minimum perforated surface area = 3500 cfm \div 25 cfm/ft² = 140 ft² (prefer all the floor be perforated)
4. Fan information must be found from fan literature and/or extension literature.
Static Pressure = 5 inches of water
Fan Horsepower = 7 hp
5. The fan is started after five hours of tempering, so there would be 500 bu/hr \times 6 hr = 3000 bushels in the bin at fan start up. It should take four hours more to fill the bin and cooling should be completed about six hours after the last hot sunflower has been added.

IN-STORAGE COOLING

In-storage cooling is different than dryeration because the grain is dried to the safe storage moisture content in the dryer, then just cooled in storage. Since the grain is dry coming from the dryer, do not delay cooling to allow for tempering. If cooling is delayed, condensation may accumulate on the bin sidewalls and in the adjoining grain. This would necessitate moving the grain to mix it, eliminating the advantage for in-storage cooling of putting the grain in storage directly from the dryer.

The cooling rate should equal the filling rate since condensation may form if the grain is allowed to temper. This airflow rate for in-storage cooling is the same as for dryeration. The airflow direction and equipment are also the same for in-storage cooling as for dryeration. Refer to the dryeration section for this information.

Dryer capacity will increase since the grain is not cooled in the dryer. The amount of the increase will vary depending on what percentage of the total dryer time was used for cooling. The increase will not be as large as in dryeration because some drying is accomplished by dryeration. The advantage of in-storage cooling is to eliminate the need for a dryeration bin and extra handling.

An aeration system is usually not adequate for in-storage cooling. If an aeration system for 7000 bushels of corn is sized at 1/5 cfm/bu, the airflow rate is 1400 cfm. Since cooling requires 12 cfm/bu/hr, the corn can be cooled at a rate of 1400 cfm \div 12 cfm/bu/hr = 117 bushels per hour. The aeration system is adequate if corn is not added to the bin faster than 117 bushels per hour.

IN-STORAGE COOLING ALTERNATIVE FOR SMALL GRAINS

Small grains may not need to be cooled as rapidly as other later harvested crops, so it may be possible to use properly sized aeration systems for in-storage cooling.

Rapid cooling is required to limit the amount of condensation. Under some temperature conditions, condensation may not be a problem and cooling time may be lengthened. The condensation problem is reduced if there is little difference between the grain temperature and outdoor temperature. For example, if the grain temperature is 100°F and the outdoor temperature is 80°F, the condensation problem will be less than if the grain temperature is 140°F and the outdoor temperature is 40°F. Since small grains are usually dried at lower drying temperatures and during warm weather, the amount of condensation should be tolerable. The amount of condensation should be monitored, however, because condensation may not be eliminated.

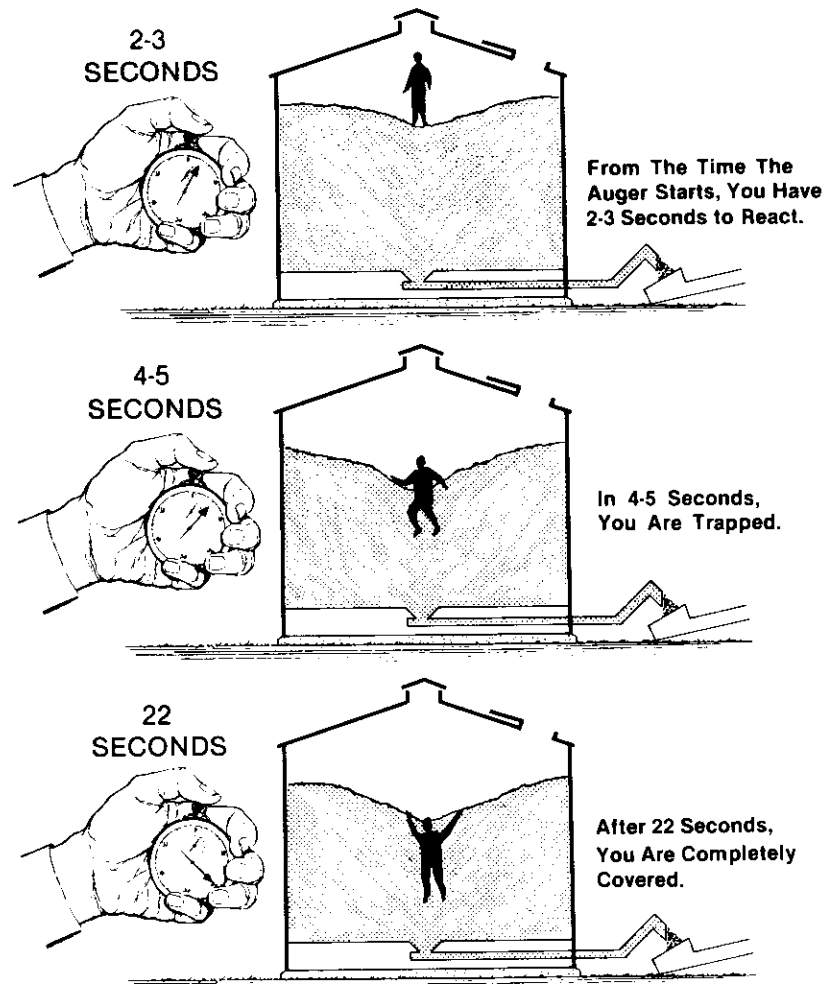
To limit condensation on the bin roof, air can be pulled down through the grain. The last grain to be cooled is at the bottom when air is pulled down through the grain. Measure the temperature of the air being exhausted to estimate when the grain has been cooled. Air will go around pockets of fines, so measuring the air temperature will not indicate the temperature of these pockets. Probe the grain to

check the temperature in several spots to assure that the grain has been cooled. If condensation is not a problem, pushing the air up allows the grain temperature to be checked at the top to determine when cooling has been completed.

The time available for cooling is short even without condensation because warm kernel temperatures encourage spoilage. Cool the grain in three days or less even if it has been dried to the storage moisture content in the dryer. If the grain is above safe storage moisture content, spoilage is likely within three days. An airflow rate of at least 1/5 cfm/bu is required to cool the grain in three days. If an aeration system is sized to provide at least 1/5 cfm/bu, then the aeration system should be adequate for in-storage cooling of small grains.

Moisture and warm grain provide an ideal environment for spoilage. Therefore, the grain must be monitored to determine the extent of any condensation and to verify that all the grain has been cooled. Management is the key to success.

FLOWING GRAIN CAN KILL YOU!



Helping You Put Knowledge To Work

NDSU Extension Service, North Dakota State University of Agriculture and Applied Science, and U.S. Department of Agriculture cooperating. William H. Pietsch, Director, Fargo, North Dakota. Distributed in furtherance of the Acts of Congress of May 8 and June 30, 1914. We offer our programs and facilities to all persons regardless of race, color, sex, religion, age, national origin, or handicap; and are an equal opportunity employer. 2M-7-90