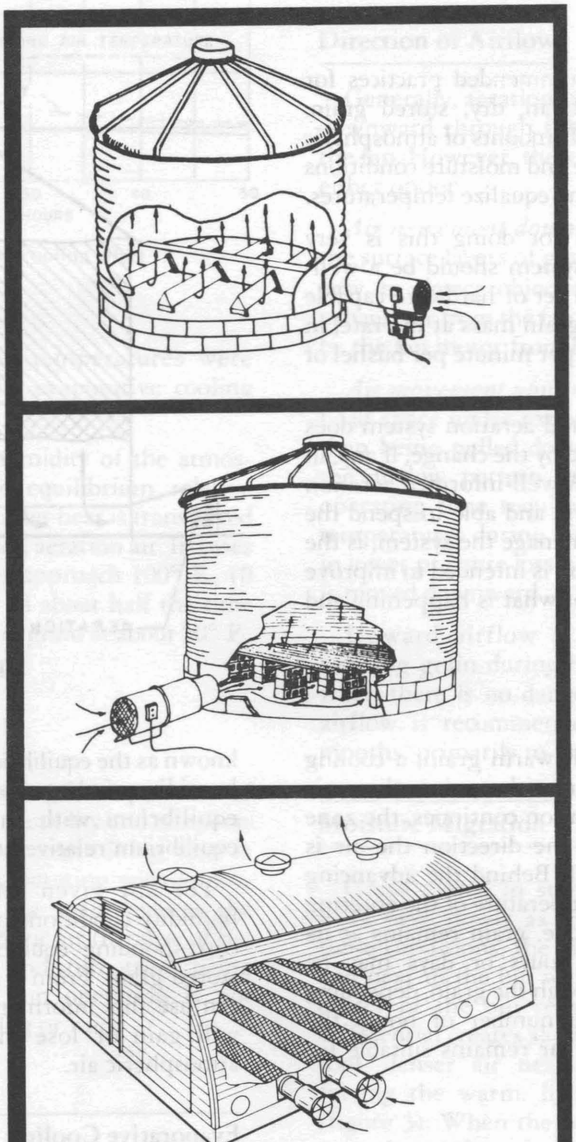
1-5-88
new 3x

Texas Agricultural Extension Service



AERATION OF STORED GRAINS

Texas Agricultural Extension Service • Zerle L. Carpenter, Director • The Texas A&M University System • College Station, Texas

AERATION OF STORED GRAIN

Richard E. Withers, Jr.*

Aeration is one of the recommended practices for maintaining the quality of clean, dry, stored grain. Aeration is the forcing of small amounts of atmospheric air with desirable temperature and moisture conditions through stored grain to cool and equalize temperatures.

Obviously, the mechanism for doing this is very important. The air delivery system should be a well-engineered, properly installed set of hardware capable of delivering air through the grain mass at the rate, in most cases, of 1/10 cubic foot per minute per bushel of stored grain.

However, the best engineered aeration system does not insure success, as measured by the change, if any, in grain quality during storage. A well-informed aeration system operator, who is willing and able to spend the time necessary to adequately manage the system, is the key to success. This information is intended to improve an operator's understanding of what is happening and how things should be done.

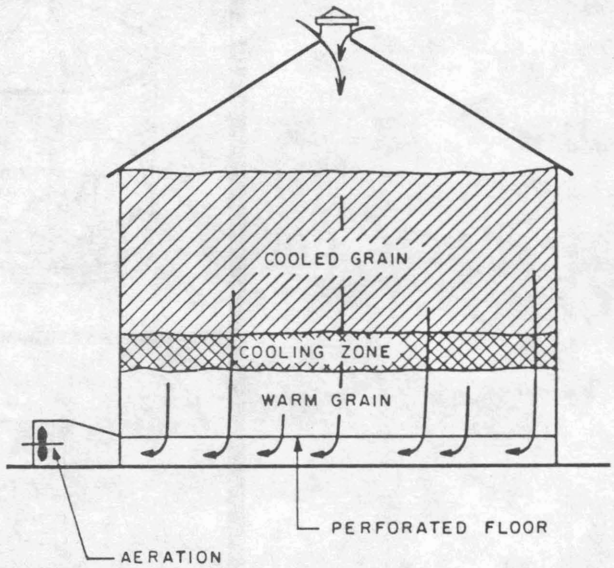


Figure 1. Cooling zone.

Cooling Zone

When air is forced through warm grain, a cooling zone forms first in grain nearest the point where air enters the grain mass. As aeration continues, the zone moves through the grain in the direction the air is moving, as shown in figure 1. Behind the advancing zone, grain approaches the temperature of the entering air. In front of the cooling zone, grain remains at its initial temperature. Several hours or days may be required to move the zone through the grain, depending on the airflow rate and the number of hours the condition of the atmospheric air remains suitable for cooling the grain.

Equilibrium Conditions

When atmospheric air moves through stored grain, there is an exchange of both heat and moisture until the air and grain have comparable temperatures and moisture contents. When there is no longer any transfer of heat or moisture, an equilibrium condition between the atmospheric air and the stored grain exists. When this occurs, the moisture content of stored grain is known as the equilibrium moisture content. The relative humidity of the atmospheric air, when the air is in equilibrium with the grain, is referred to as the equilibrium relative humidity.

For any given set of temperature and relative humidity conditions of the atmospheric air, there is a corresponding equilibrium moisture content for the stored grain. From a practical standpoint, an operator can use this information to determine if stored grain will gain or lose moisture when in contact with atmospheric air.

Evaporative Cooling

When the relative humidity of the atmospheric air is below the equilibrium relative humidity, moisture evaporates from the grain during the aeration process, and the grain temperature decreases as a result of the evaporative cooling effect. The amount of cooling from evaporation may be as much as 50 percent or more of the total heat removed. An illustration of this phenomenon is shown in figure 2. In this example, grain was aerated with atmospheric air at a temperature comparable to that of the grain (about 90° F.) but with a relative humidity below that of the equilibrium relative humidity. As a result, moisture was evaporated

*Extension agricultural engineer, The Texas A&M University System.

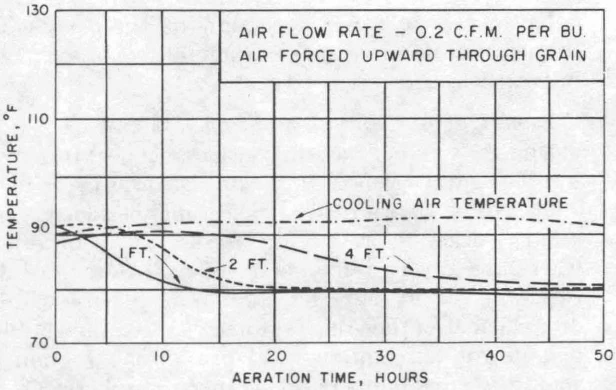


Figure 2. Evaporative cooling effect.

from the grain and the grain temperatures were decreased 10° F. because of the evaporative cooling process.

In some cases, the relative humidity of the atmospheric air is higher than the equilibrium relative humidity, initially, but decreases after heat is transferred from hotter, stored grain to cooler, aeration air. In cases where initial grain temperatures approach 100° F., 10 to 15 degrees cooling can occur in about half the time required for the same reduction in grain at about 50° F., because of the evaporative cooling.

Suitable Weather

Consider the moisture content and temperature of the stored grain and the relative humidity and temperature of the atmospheric air when determining what is suitable weather. In most cases, aerating with atmospheric air 10° F. cooler than the grain reduces the relative humidity of the atmospheric air (because of the heat gain) enough to prevent moisture from being added to the grain. However, fan operation is not normally recommended during fog or rain.

Time Required for Cooling

The time required to move a cooling zone through a grain mass depends on the airflow rate, characteristics of the grain mass and the amount of evaporative cooling. Typically, however, with 1/10 cubic foot per minute per bushel aeration, 70 to 100 hours of fan operation in the summer and 160 to 180 hours in the fall and winter are required to cool grain sorghum to near atmospheric temperature. Aeration with 1/20 cubic foot per minute per bushel requires about twice as many hours of operation.

The number of days required for cooling a grain mass depends on the number of hours per day that are suitable for aeration. In the summer and early fall in South Texas, only a few hours per day may be suitable, and as many as 18 to 20 days may be required to cool the grain. Later in the fall and during winter, more suitable weather is usually available and less time is required.

Direction of Airflow

Generally, aeration systems are designed to move air downward through the grain and exhaust it through the fan. However, there are advantages associated with either option.

Air movement downward prevents condensation on the surface layers of grain and on the bin roof, makes it easy to detect objectionable odors by checking the exhaust air from the fan and prevents the heat generated by the fan motor from being added to the grain.

Air movement upward forces the heat trapped in the head space under exposed roofs out at the top rather than being pulled down through the grain, improves the airflow pattern between ducts, reduces the fan operating time required to lower and equalize grain temperatures during bin loading at harvest and results in lower pressure losses in aeration ducts than when air is moved downward.

Upward airflow is generally recommended for aerating grain during bin loading and during periods when there is no danger of condensation. Downward airflow is recommended during the fall and winter months, primarily to prevent condensation.

Moisture Migration

Grain placed in storage during the warm months loses heat slowly as the weather gets colder. Under these conditions, the air in the grain near the surface and next to the bin walls cools first, while that in the center of the bin remains warm. This temperature differential creates slowly moving air currents with the cool, denser air near the walls moving downward forcing the warm, lighter air in the center upward (figure 3). When the warm air reaches the cold grain near the surface, condensation may occur. If this is allowed to continue, accumulated moisture may promote insect activity, mold growth and spoilage in the upper layers of stored grain. To control moisture migration, use aeration to equalize the temperature throughout the grain mass.

Fan Operation

It is difficult, if not impossible, to specify a fan operation schedule suitable for every situation. Consider the many variables associated with the aeration system, the atmospheric air conditions and conditions of the

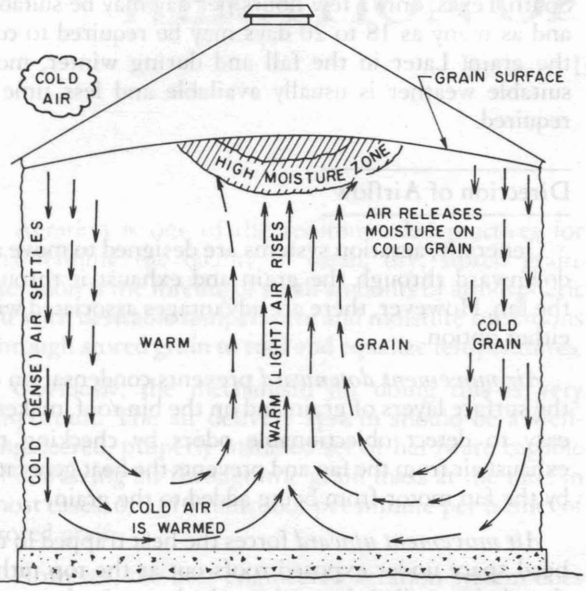


Figure 3. Example of moisture migration.

stored grain when deciding on a schedule. The importance of knowing what happens when atmospheric air is forced through stored grain cannot be overemphasized. A thorough understanding of the information included in the "Equilibrium Conditions" and the "Evaporative Cooling" sections of this leaflet should enable an aeration system operator to apply "reason" in regulating fan operation. Frequently checking the temperature and moisture conditions of the stored grain as well as a knowledge of the atmospheric air conditions are a must for proper fan operation. Automatic controls can be used to facilitate the process.

Fan operation varies depending on the purpose of the aeration system. Fan operation for two of the more important uses is discussed below.

Removing harvest and dryer heat. Grains harvested during the summer pick up considerable heat from the sun. The grain warms as it remains in trucks in the field and at the elevator. Additional heat may be added if the grain is dried before storing because the grain often leaves the dryer at temperatures well over 100° F. Aeration is very effective in removing harvest and dryer heat after the grain is stored. To accomplish this, operate the fan continuously until all of the grain is about the same temperature as the atmospheric air. A minimum airflow rate of 1/20 cubic foot per minute per bushel is recommended, but a rate of 1/10 cubic foot per minute per bushel is preferred.

Maintaining quality of stored dry grain. The usual procedure is to operate aeration fans only when the air temperature is at least 10° F. lower than the temperature of the grain. However, when grain with temperatures of 90° F., or higher, goes into storage, it may be desirable to operate the fan with less than a 10° F. temperature differential. In this case, the relative humidity of the air is secondary, since moisture normally is transferred from the grain to the air during cooling. Once the fan is started, continue aeration according to the above procedure until the entire bin of grain has been cooled and the temperatures equalized.

Aeration begun in the summer should continue through the fall and winter until grain temperatures are reduced to at least 50° F. in all parts of the bin. Stored grain at 50° F. can be moved during the summer months with little danger of moisture condensation and subsequent spoilage.

Issued in furtherance of Cooperative Extension Work in Agriculture and Home Economics, Acts of Congress of May 8, 1914, as amended, and June 30, 1914, in cooperation with the United States Department of Agriculture. Zerle L. Carpenter, Director, Texas Agricultural Extension Service, The Texas A&M University System.
3M—11-87