## Questions and Answers on Grain Storage and Drying

**Question 1**: How many cfm/bu does it take to "hold" 17, 19, 21 & 25% moisture corn?

The safe storage time for corn depends on the moisture content and the temperature. See the Safe Corn Storage Periods for specifics. Remember that during storage the corn produces heat and moisture. Aeration is needed to keep the corn cool. The rate of heat production increases with moisture content, thus the amount of aeration should be increased with higher moisture contents. The higher the moisture the higher the risk of the corn going out of condition, and the shorter the time the corn should be stored.

Table 1. Safe Corn Storage Periods (Number of days)*

| Storage Air | Corn Moisture Contents (Wet Basis) | | | | | | |
|---|---|---|---|---|---|---|---|
| Temperature | 15% | 17% | 19% | 21% | 23% | 25% | 30% |
| 75 | 115. | 37. | 16. | 9. | 6. | 5. | 3. |
| 70 | 154. | 49. | 22. | 12. | 8. | 6. | 4. |
| 65 | 206. | 66. | 29. | 16. | 11. | 8. | 5. |
| 60 | 275. | 88. | 39. | 22. | 14. | 10. | 6. |
| 55 | 414. | 133. | 58. | 32. | 21. | 14. | 8. |
| 50 | 621. | 199. | 88. | 48. | 30. | 21. | 12. |
| 45 | 931. | 299. | 131. | 72. | 45. | 32. | 18. |
| 40 | --- | 448. | 197. | 107. | 68. | 48. | 27. |
| 35 | --- | 671. | 295. | 161. | 102. | 72. | 41. |

* Based on 0.5% dry matter decomposition. Proper aeration management is required to keep corn at the temperatures.

Grain deterioration is cumulative. Use of the above table should accumulate percentage of the safe storage period use. For example, assume corn was harvested at 25% moisture and allowed to set in a truck overnight (12 hours) before unloading. The average temperature in the truck was 70 degrees F and the corn was then placed in a holding bin equipped with a cooling fan. If the bin was cooled down to 40 degrees F in 2 days, how long can the corn be held at 40 degree F without excessive deterioration?

.5 day / 6 days = 8.3% of the safe storage time was setting in the truck.

2 days / 14 days = 14.3% of the allowable time was used during the 2 days of cooling. Assumed 55 degree F average temperature during cooling.

8.3 + 14.3 = 22.6% of the safe storage period was used in the unloading and cooling period.

Thus: 77.4% of the 48 days or 37 days of safe storage remain at 40 degree F.

**Question 2.** What are the maximum allowable corn moisture contents when using a natural air grain drying system?

Maximum allowable corn moisture contents are largely dependent upon system airflow rates and local weather conditions. The following table shows maximum moisture contents for several locations and harvest dates for average fall Nebraska conditions. Grain placed in a bin with higher moisture contents than shown will most likely results in spoilage. The data presented assumes continuous fan operation until the grain is dry.

**Table Q2.** Maximum Harvest Moisture Content (Based on 1.0 cfm/bu airflow).

| Location | Harvest Dates | | | |
|---|---|---|---|---|
| | 9/15 | 10/1 | 10/15 | 11/1 |
| Soiux City | 19.0 | 20.0 | 21.5 | 23.0 |
| Lincoln | 19.5 | 20.0 | 20.5 | 23.0 |
| Grand Island | 20.0 | 21.5 | 22.0 | 24.5 |
| North Platte | 21.0 | 22.5 | 23.0 | 25.5 |
| Scottsbluff | 22.5 | 24.0 | 24.5 | 26.0 |

For other airflow rates see NebGuide G85-760, "Natural Air Corn Drying."

**Question 3.** What horsepower requirements are needed for natural air drying?

Because extensive periods of time are required to natural air dry grain proper system design is important to drying efficiency. Generally, natural air drying systems should be designed (Table Q3b) where airflows rates of 1.0 cfm/bu can be achieved with using less than 1.5 hp per 1,000 bushels of grain. This means limiting the grain depth in many cases as shown in table below. One should note that the horsepower requirement more than doubles when corn depth increases from 16 to 22 feet.

**Table Q3a**. Estimated Horsepower Requirements (HP/1,000 bu) to deliver 1.0 cfm/bu.

| Depth in ft | Corn | Grain Sorghum |
|---|---|---|
| 10 | 0.47 | 0.71 |
| 12 | 0.47 | 1.04 |
| 14 | 0.54 | 1.45 |
| 16 | 0.74 | 1.97 |
| 18 | 0.98 | 2.57 |
| 20 | 1.26 | ---- |
| 22 | 1.58 | ---- |

**Table Q3b**. General airflow requirements:

0.10 - 0.20 cfm/bu for aeration of dry grain
0.25 - 0.40 cfm/bu for holding 18% grain during the winter months.
0.50 - 1.00 cfm/bu for cooling hot grain from a dryer
1.00 - 2.00 cfm/bu for natural air grain drying higher airflows are required for heated air drying. The airflow rate should be increased as the drying air temperature is increased.

**Question 4**: How much can we expect to lower grain moisture percentage with only aeration between November 1 and March 1?

With aeration, even if the fan is ran continuously, the grain would dry very little even during the fall and spring. With 0.1 or 0.2 cfm/bu, there is not enough air to change the moisture content over 1% percent or so. With higher airflow rates (> 1 cfm/bu), corn can be dried to about 17% during the winter months, but the drying process will be very slow. Likewise, the over-dried grain in the bin can be rewetted to about 16 %, but again this rewetting process is very slow.

**Question 5**: How long will it take with a given cfm/bu and varying temperature and varying humidity to naturally dry grain from 23% to 15%?

The attached table shows the number of days required for air at various temperatures and relative humidities to carry away the moisture required to dry from 23 to 15% moisture. Note that a dryer is not 100% efficient and that the number of days will depend on the initial and final moisture contents.

**Table Q5**. Number of days for the air to carry away the moisture to dry from 25.0% to 15.0% moisture with 1 cfm/bu. (Divide days by cfm/bu for other airflows.)

| | Relative Humidity | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Temp | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 |
| 40 | 36.8 | 40.6 | 45.1 | 50.6 | 57.3 | 68.3 | 81.8 | 101.7 | 133.7 |
| 45 | 32.5 | 35.8 | 39.8 | 44.6 | 50.5 | 59.8 | 71.4 | 88.3 | 115.2 |
| 50 | 28.9 | 31.8 | 35.3 | 39.6 | 44.8 | 52.9 | 63.1 | 77.8 | 100.9 |
| 55 | 25.9 | 28.5 | 31.7 | 35.5 | 40.2 | 47.3 | 56.4 | 69.3 | 89.5 |
| 60 | 23.4 | 25.8 | 28.6 | 32.1 | 36.3 | 42.8 | 50.9 | 62.5 | 80.4 |
| 65 | 21.2 | 23.5 | 26.1 | 29.3 | 33.1 | 39.0 | 46.3 | 56.8 | 72.9 |
| 70 | 19.4 | 21.5 | 24.0 | 26.9 | 30.4 | 35.8 | 42.5 | 52.1 | 66.7 |
| 75 | 17.9 | 19.9 | 22.1 | 24.9 | 28.2 | 33.1 | 39.3 | 48.1 | 61.5 |
| 80 | 16.6 | 18.4 | 20.6 | 23.1 | 26.2 | 30.8 | 36.6 | 44.7 | 57.1 |

**Question 6**: How much does depth of grain affect ability to dry grain?

The rate of grain drying is directly proportional to the airflow rate (cfm/bu) in most dryers. The static pressure and the horsepower required to deliver the air increases very rapidly as the grain depth increases. For example, to deliver 1 cfm/bu through 7,000 bushels of corn in a 24 foot diameter bin (19 ft of grain depth) requires a 10 hp fan. The same airflow in a 27 foot diameter bin (15 ft of grain depth) requires only 5 hp. Remember, the energy cost of operating a 5 hp fan is half of that for 10 hp, but the drying rate is the same. In addition the 27 ft diameter bin costs less.

**Question 7**: What is the approximate relationship between cfm and horsepower of fans?

Table Q2. Rule of Thumb - Bushels per Fan Horsepower

| | | -- Max Depth* --- | |
|---|---|---|---|
| cfm/bu | Bushels/Horsepower | Corn | Grain Sorghum |
| 0.2 | 5,000** | 45' | 28' |
| 0.5 | 2,000 | 27' | 17' |
| 1.0 | 1,000 | 18' | 12' |
| 2.0 | 500 | 12' | 8' |

* the bushels/horsepower decrease with deeper depths
** note: use a fan 0.75 horsepower or larger

**Question 8**: What is the difference between air flow requirement (cfm/bu) between corn and grain sorghum?

The airflow requirement, in cfm/bu, for both corn and grain sorghum is approximately the same. The problem is that grain sorghum creates more static pressure and thus a higher horsepower fan is required to deliver the same amount of airflow. Generally, it requires twice the horsepower to provide the same airflow rates through grain sorghum.

**Question 9**: How much can you raise air temperature by naturally dry grain?

Early in the fall, no supplemental heat is needed. With an axial fan there is an approximate 2 degree F temperature rise by pulling the air over the electric motor.

Later in the fall, it would be good to add 3 to 6 degree F temperature rise to lower the humidity of the drying air. The problem is that most burners are too large, providing over 1 Million BTU/hr, while 200,000 to 300,000 would be plenty. With the large burners, most producers over dry the grain in the bin, frequently to 10 % or below on the bottom layers. If adding heat, turn the thermostat as low as possible, maybe 50 degree F and only run the burner part of the day, perhaps 10 to 12 hours. A humidistat to control the burner would be another option to reduce over-drying of grain.

**Question 10**: For best drying efficiency and maintaining grain quality what temperature should the drying chamber be ran at with bins that have a drying floors but no stiration equipment?

See the natural air answer above.

**Question 11**: For best efficiency and maintaining grain quality what temperature should you run the drying chamber at with a bin that has stiration equipment?

With an grain drying system, the drying rate depends on the ability of the air to carry away the.moisture. For best grain quality, use a temperature as low as practical to get the grain dried in the required time. For many systems the airflow rate is too low. If airflow rate is low do not fill the bin completely full and a higher airflow will result.

**Question 12**: Should I let my aeration fan run continuously or shut it off during wet weather?

This depends entirely on the current situation. If the grain is dry and the grain temperature is at the normal (2 week) average temperature for that time of the year, the fan can be shut off. If, however, the grain needs to be cooled, or is not dry (representing a higher risk situation), it may be wise to let the fan run to keep the grain cool.

**Question 13**: When considering grain that is placed in flat storage or bin storage that has aeration tubes or floors that are designed for aeration, can producers expect to do anything except storage 12-15% grain in these situations?

No, the tubes are normally sized for 0.1 or 0.2 cfm/bu and used only to control grain temperatures in the storage.

**Question 14:** When drying with a NECO, Circuflow, or Shivvers system which drys on the floor and pulls the dry grain off of the floor and puts it in another bin to cool down, what temperature should the drying chamber be operated at for maximum efficiency and maintain grain quality?

This dryer has excellent energy efficiency regardless of the temperature. The problem is that it is detrimental to grain quality. The driest grain is in contact with hottest air, which lowers the quality of the dried grain. For best results, run the system with the temperature as low as practical to get the drying completed in the desired time. For example, 120 degree F or lower would produce high quality grain, but many producers may want to use higher temperatures for faster drying times.

**Question 15**: A producer has a wood corn crib that was converted to shelled grain storage bin, and is 30 feet long, 12 foot high and 12' wide with a tunnel covered with perforated flooring. The tunnel is 2' wide. How many cfm/bu are required on 22 - 23% corn?

Assuming the tunnel is in the floor, the maximum airflow through the tunnel is 30 cfm/ft2 * 2' wide * 30' long = 1800 cfm. This is assuming that the tunnel is at least 15" deep. This is about 0.5 cfm/bu which will hold 23 % corn for a month or two. Airflow distribution will be poor in the wood corn crib.

**Question 16**: A producer has a 16,000 bu bin with a cone floor and a 12" aeration tube that goes to the bottom of the cone. How many cfm are required to keep 22 - 23% corn until next spring?

First, it should be noted that this grain can not be held until spring. Using a maximum air velocity of 1500 fpm (see Table), one 12" aeration tube can carry a maximum of 1200 cfm, which is less than 0.10 cfm/bu on 16,000 bu. On 16,000 bushel of 23% corn, this amount of airflow would hold the corn for a few days, maybe a week, but no more!!

**Table Q16**. Aeration Duct Design Guidelines

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Maximum air velocity in the duct:
- with positive pressure system (fan pushing):
  - 1500 fpm, 2000 fpm if duct < 25 feet long
- with negative pressure system (fan pulling):
  - 1000 fpm, 1500 fpm if duct < 25 feet.

Maximum velocity from the surface of the duct: 30 fpm

Ratio of longest to shortest path the air takes in the grain mass:
- the duct divided by the longest path 1.5 ideal, 1.7 more realistic

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**Question 17**: How much differential should there be between air temperature and grain temperature?

For aeration of dry grain, try to keep the grain temperatures equalized in the bin, and keep the temperature at the normal (2 week) average temperature, or within 10 degrees of the air temperature. This practice will reduce convection currents in the grain mass.

Table 1. Equilibrium Moisture Contents for Shelled Corn

| Air Temp | Relative Humidity 10 | 20 | 30 | 40 | 50 | 60 | 70 | 80 | 90 |
|---|---|---|---|---|---|---|---|---|---|
| 30 | 5.5 | 7.9 | 9.8 | 11.4 | 13.1 | 14.8 | 16.6 | 18.7 | 21.5 |
| 40 | 5.2 | 7.5 | 9.2 | 10.9 | 12.4 | 14.0 | 15.8 | 17.8 | 20.6 |
| 50 | 5.0 | 7.1 | 8.8 | 10.4 | 11.9 | 13.4 | 15.1 | 17.0 | 19.7 |
| 60 | 4.8 | 6.8 | 8.4 | 9.9 | 11.4 | 12.9 | 14.5 | 16.4 | 19.0 |
| 70 | 4.6 | 6.5 | 8.1 | 9.5 | 11.0 | 12.4 | 13.9 | 15.8 | 18.3 |
| 80 | 4.4 | 6.3 | 7.8 | 9.2 | 10.6 | 12.0 | 13.5 | 15.3 | 17.7 |
| 90 | 4.2 | 6.1 | 7.6 | 8.9 | 10.2 | 11.6 | 13.0 | 14.8 | 17.2 |

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Table 2. Safe Storage Moisture

| To be stored | Corn | Sorghum | Soybeans | Wheat |
|---|---|---|---|---|
| Until Spring | 15.5 % | 15.5% 14% | | |
| 1 year | 14% | 14 % | 12% | 13% |
| 2-3 years | 13% | 13 % | | |

* with aeration management

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Table 4. Rule of Thumb - Bushels per Fan Horsepower

| cfm/bu | Bushels/Horsepower | -- Max Depth* --- Corn | Milo | |
|---|---|---|---|---|
| 0.2 | 5,000** | | 45' | 28' |
| 0.5 | 2,000 | 27' | 17' | |
| 1.0 | 1,000 | 18' | 12' | |
| 2.0 | 500 | 12' | 8' | |

* the bushels/horsepower decrease with deeper depths
** note: use a fan 0.75 horsepower or larger

Table 5. Guidelines for Natural Air Drying

| Moisture | Cfm/bu |
|---|---|
| 18 % | 0.75 |
| 20 % | 1.00 |
| 22 % | 2.00 |
| 24 % | 4.00 |
| 26 % | 8.00 |

Note: a fan will deliver a higher cfm/bu when only partially filled. It is best to request a fan performance analysis for your fan and bin, from your county agent or Tom Thompson, 402-472-1642.

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Table 6. Days for the air to carry away the moisture to dry from 25.0 % to 15.0 % moisture with 1 cfm/bu. Divide days by cfm/bu for other airflows

| | Relative Humidity | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| Temp | 40 | 45 | 50 | 55 | 60 | 65 | 70 | 75 | 80 |
| 40 | 36.8 | 40.6 | 45.1 | 50.6 | 57.3 | 68.3 | 81.8 | 101.7 | 133.7 |
| 45 | 32.5 | 35.8 | 39.8 | 44.6 | 50.5 | 59.8 | 71.4 | 88.3 | 115.2 |
| 50 | 28.9 | 31.8 | 35.3 | 39.6 | 44.8 | 52.9 | 63.1 | 77.8 | 100.9 |
| 55 | 25.9 | 28.5 | 31.7 | 35.5 | 40.2 | 47.3 | 56.4 | 69.3 | 89.5 |
| 60 | 23.4 | 25.8 | 28.6 | 32.1 | 36.3 | 42.8 | 50.9 | 62.5 | 80.4 |
| 65 | 21.2 | 23.5 | 26.1 | 29.3 | 33.1 | 39.0 | 46.3 | 56.8 | 72.9 |
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with positive pressure system 1500 fpm, 2000 fpm if duct < 25 feet long

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Ratio of longest path from the duct divided by the longest path 1.5 ideal, 1.7 more realistic