LARGE GRAIN BIN STORAGE

Supplement to NAD factsheet

Grain bins are getting **BIGGER**!

The average size of bins used to store grain crops has increased significantly. In the 1980s the largest bin sizes typically ranged from 2,000 to 4,000 bushels with grain depths of 10 to 20 ft. More recently, bin sizes have grown to as large as 20,000 to 50,000 bushels with grain depths reaching 20 to 40 ft. This factsheet has been compiled to provide producers with strategies for managing grain in large bins and considerations to keep in mind when upgrading to larger storage volumes.

General Storage Management Principles Review

- Hot/wet grain may spoil during storage.
- Spoilage = **lost revenue.**
- Risk of spoilage depends on both **temperature** and **moisture content.**

Grain temperature and moisture content can be managed in a bin by passing air through the grain.

Aeration = Temperature Control.

- Used to cool grain (provided ambient air temperature is less than that of the grain) and create a uniform temperature profile throughout the bin.
- Can be accomplished with low airflow rates (0.1 cfm/bu).

Natural Air Drying (NAD) = Moisture & Temp Control.

- Reduces grain moisture content provided the incoming air has the "capacity to dry" (based on temperature and relative humidity difference between the ambient air and that of the grain; refer to NAD factsheet).
- Requires mid airflow rates (1 cfm/bu).

Airflow rate is the key factor that differentiates the two strategies. Airflow rates that can be achieved within a grain mass depend on fan type/size and resistance to airflow.

NAD in Large Bins is Challenging to Manage

Airflow rates required for NAD are hard to achieve in larger bins, which means that drying in larger bins can be a challenge. Further, larger storage volumes mean higher risk of spoilage. Why is it hard to achieve these airflow rates?

Greater Depth of Grain -> Greater Resistance to Airflow

Static pressure is an indicator of airflow resistance and is measured in inches of H_2O. The measure of static pressure (airflow resistance) in combination with a specific fan chart can be used to determine the airflow rate that can be achieved in a particular type and depth of grain. (Figure 1: example of static pressure at four air flow rates for wheat and barley).

The relationship between airflow resistance and grain depth is exponential, meaning that the static pressure increases significantly at higher depths.

Conversely, these charts can also be used to size a fan for a particular type and depth of grain based on the airflow resistance that it needs to overcome.

Note: These charts have only been experimentally verified for depths up to 25 ft.

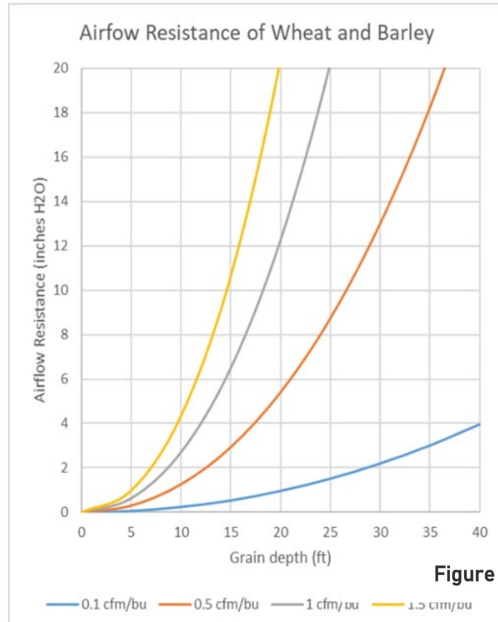

Figure 1

Airflow Resistance Curves Are Commodity Specific

Grain type heavily influences the airflow resistance experienced when pushing air through grain. Smaller seeds = smaller voids between seeds = greater airflow resistance

Canola will present a greater airflow resistance than wheat for the same depth of grain. In other words, an aeration or NAD fan system in a large bin designed for storing wheat may not be suitable for drying canola.

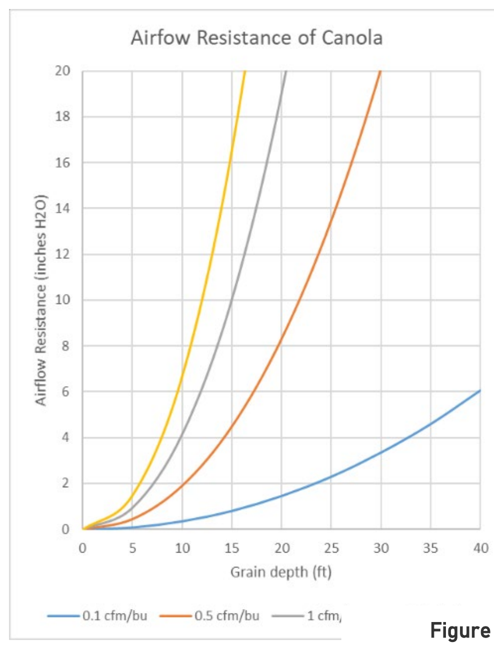

Figure 2

NAD Airflow Rates Contribute to Back Pressures

The final factor that influences the amount of airflow resistance in a grain bin is airflow rate. In other words, the faster you try to push air through the grain, the more back pressure or resistance is experienced. Figures 1 and 2 show that the steepness of the curves is greater for higher airflow rates that are needed for natural air-drying.

Standard Fan Sizes Are Inadequate

If a greater grain depth results in a higher airflow resistance, then it makes sense that the fan power requirement will also increase. Example fan curves for common 10 hp fan types are shown in Figure 3. This figure demonstrates that airflow capacities are reduced significantly when trying to overcome the higher static pressures that are required for greater depths or increased airflow rates.

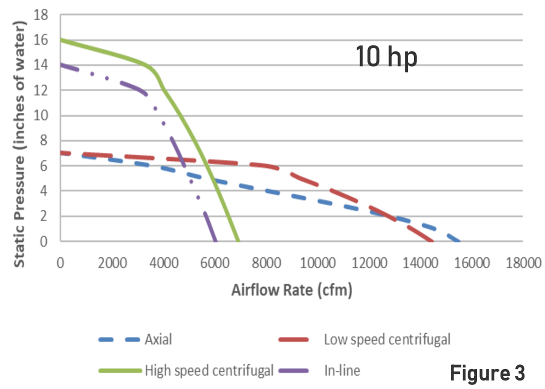

Figure 3

Example: In an NAD (1 cfm/bu) application it would be expected that there would be 12 in. H_2O of airflow resistance for wheat at a 20 ft. depth (Figure 1). At this static pressure, a 10 hp, high-speed centrifugal fan may supply 5000 cfm of total airflow; however, the 1 cfm/bu will only be achievable for a 5000-bushel bin containing wheat at this depth. Comparatively, 20 in. H_2O of airflow resistance would be expected for canola at the same depth (Figure 2) and a 10 hp fan would not be adequate.

Careful attention must be paid to the shape of the fan curve, a steep drop-off indicates unstable operation at higher airflows.

Larger fans (up to 80hp, >20 in. H_2O) are available; however, they come with increased utility requirements. Most small to medium sized farms only have access to single phase electrical utilities. Larger fans will often require an upgrade to 3-phase power which can be a significant capital cost to bring in. A fan selection tool: https://bbefans.cfans.umn.edu/ can be used to size larger fans for these applications.

Solutions for Overcoming Challenges in Large Bins

The following are potential solutions to overcome the challenges of increased air flow resistance with greater depths of grain and where possible, attempt to avoid the need for costly utility upgrades.

Reduce Grain Depth for NAD

In cases where high horsepower fans are not practical, power requirements may be reduced by a reduction in grain depth. In other words, if grain needs to be dried, only fill the bin to a depth where the higher airflow rates can be achieved by the smaller fan.

Example: Canola is particularly difficult to dry in large bins. A 10 hp, high-speed centrifugal fan can overcome 12-14 in. H_2O in 4000 bushels of grain; indicating a maximum depth of 17 ft. for this scenario is reasonable. Correcting for bin diameter in wider bins; this scenario would correspond to a maximum bin diameter of approximately 20 ft. to achieve the minimum airflow rate of 1 cfm/bu required for NAD.

Surface Levelling

Normal grain bin filling results in a peaked profile; levelling is meant to reduce the depth of grain in the center of the bin. This practice does not reduce airflow resistance as the average depth does not change, but it is recommended to ensure uniform airflow through the grain (air will travel the path of least resistance, i.e. areas of lesser depth – edges). Levelling the peak after filling (only proceed if safe to so) is the preferred method rather than using a gravity spreader during filling.

Different Distribution Systems (lack of research)

Ducting and airflow distribution systems between the fan and grain add to the overall airflow resistance experienced by an aeration fan. More restrictive ducting systems will contribute a greater amount of static pressure above and beyond that produced by the grain. Therefore, a large opening plenum (and ducting) and fully perforated floors, in the case of flat-bottomed bins, will present the least amount of added static pressure that results from the distribution system.

Novel ducting systems (e.g. Cross flow aeration systems) that capitalize on lower airflow resistances in the horizontal direction for taller bins are now available. These systems have not been experimentally validated, but could provide future options for lowering fan power requirements on larger bins.

Further, certain distribution systems (e.g. cross-duct, Y-duct, rocket, etc.) can affect the uniformity of airflow within a bin, particularly for hopper bottom bins. Current research is not sufficient to quantify the advantages and disadvantages between these unique systems in terms of airflow uniformity and airflow resistance; however, it is an important characteristic to keep in mind.

Multiple Fans (not recommended)

The use of multiple smaller fans on a single bin has been considered as a way to overcome higher airflow resistances (and thus achieve higher airflow rates) without having to increase utility capacity. Multiple research projects have shown that the addition of a second fan (on hopper and flat bottom bins with varying ducting systems) is **not an efficient means of increasing airflow rate**.

For example, the addition of a 10 hp, high-speed centrifugal fan to a 15 hp system only increased the airflow by 16%, but used 66% more power.

Other Considerations for Drying Grain in Large Bins

There are some other considerations that may not be specific to storage and drying of grain in large bins, but their importance when managing and monitoring grain should be emphasized.

Layering

Many truckloads of grain are required to fill larger bins. Grains harvested at different times (even within the same day) can have different properties (e.g., MC, dockage, etc.). When these loads are put in a bin they form layers that can affect airflow uniformity within the bin. Non-uniform conditions require careful monitoring to ensure proper aeration/NAD management and reduce the risk of spoilage.

Ventilation in Headspace

Adequate ventilation is important to allow moist air to exit the bin and prevent undue load on the fan. Recommendations suggest that there be at least 1 ft.2 of vent per 1,000 cfm of air flow. Exhaust fans or powered vents can help to expel moist air from the top of the bin. This prevents condensation under the roof or on top of the grain.

Summary of Management Strategies

When building new large bins, ensure that your fans (size/type) match the tasks the bin was intended for, i.e., what type of grain do you plan on storing in it and do you plan on using NAD? This will identify the expected airflow resistance that needs to be overcome in the design. When using a large bin for a purpose it was not intended, retrofits may be required to achieve the desired airflow rates.

Unfortunately, the limitations of fan technologies and available utility capacity make NAD a difficult strategy to implement in larger bins due to the significantly higher airflow resistances at greater depths.

If higher airflow rates are required, the two options are:

1. to reduce the depth of grain, or
2. to move natural air-drying activities to smaller bins and only use large bins for storage.

Monitoring grain temperature and/or grain moisture is critical. Any monitoring system is better than nothing.

More information on PAMI research projects is available on their website.