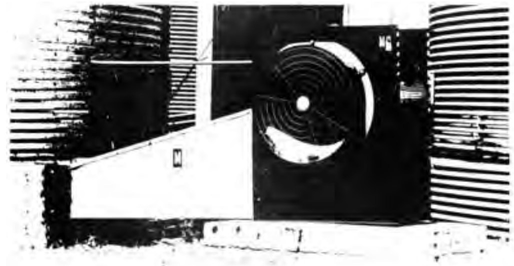

Centrifugal fan

Vane axial fan

Estimating Fan Airflow for Grain Bins

The drying fan is one of the most important, and often least understood, pieces of equipment on a grain bin drying system. For example, farmers often have questions about which is the best fan to buy. Or they wonder how satisfactorily a fan they own will dry grain. If you have any of these or other similar questions about bin drying fans, this publication will help you.

One of the most important factors to consider about a bin fan is airflow, the amount of air the fan will move through the grain. The total amount of airflow is measured in cubic feet of air per minute (cfm) that a fan will move against a specified static pressure in inches of water. A more useful factor that can be obtained or developed from total airflow is the airflow per bushel or cubic feet of air per minute per bushel (cfm/bu).

Low-Temperature Drying

The airflow that is forced through corn is the key to success for all low-temperature corn drying systems. Low-temperature drying includes drying with natural or unheated air or drying with air that has been heated (usually a maximum of 10ºF) with electricity, LP gas, or solar energy. The minimum airflow recommendations that have been determined by research to successfully dry corn are the same for unheated-air and heated-air low-temperature drying.

It is not the purpose of this bulletin to provide a complete discussion about low-temperature drying. Midwest Plan Service publication MWPS-22, "Low-Temperature and Solar Grain Drying," available from your local Iowa county extension office, contains a very complete 18-page discussion about low-temperature grain drying. Table 1, taken from MWPS-22, provides the recommended minimum airflow for the maximum moisture content for corn harvested in Iowa on or after seven specific dates.

The information in this bulletin is appropriate only for drying shelled corn in a round bin with a perforated floor. If you need to evaluate a drying fan for another purpose, such as for drying other grains, contact a competent commercial bin drying representative or extension agricultural engineer for assistance.

When comparing two drying fans, the one with higher airflow in cfm/bu will dry grain faster. For example, a low-temperature bin drying fan that delivers 25% more air will dry corn essentially 25% faster. The additional air could be the difference between satisfactory drying and spoiled corn.

The only two potential disadvantages of higher-airflow drying fans are that they are likely to have a higher initial cost, and the cost for electricity to power higher-airflow fans will usually be higher.

Because all costs, including electricity, are inflating, it is desirable to select fans that are as energy efficient as possible. This is not only a more complicated evaluation, but it is often impossible because many fan manufacturers do not furnish the necessary information about the energy efficiency of their fans. Consequently, this bulletin is limited to the procedure for estimating the capacity for fans to deliver air in cfm/bu.

Table 1. Recommended airflow for Iowa

Minimum airflow per bu. (cfm/bu)	**Corn harvested on or after**						
	Sept. 1	**Sept. 15**	**Oct. 1**	**Oct. 15**	**Nov. 1**	**Nov. 15**	**Dec. 1**
	Maximum corn moisture content, %						
1.0	19	20	20	21	23	20	18
1.25	19	20	20.5	21.5	24	20.5	18
1.5	19.5	20.5	21	22.5	24	21	18
2.0	20	21	22.5	23.5	25	21.5	18
3.0	21	22.5	23.5	24.5	26	22	18

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Table 2. Data for plotting fan and bin curves for ____-foot-diameter bin (27-food-diameter bin used in this example).

Static pressure	Example—10-hp vane axial		Your fan____-hp		Your fan____-hp	
	Col. 1 Total airflow	Col. 2 Air velocity	Col. 1 Total airflow	Col. 2 Air velocity	Col. 1 Total airflow	Col. 2 Air velocity
(inches of water)	(cfm)	(fpm)	(cfm)	(fpm)	(cfm)	(fpm)
0	23,400	40.8				
$\frac{1}{2}$	22,200	38.7				
1	20,800	36.3				
$1\frac{1}{2}$	19,400	33.9				
2	17,900	31.2				
$2\frac{1}{2}$	16,000	27.9				
3	13,400	23.4				
$3\frac{1}{2}$	9,400	16.4				
4	6,100	10.6				
$4\frac{1}{2}$	3,200	5.6				
5	500	0.9				
$5\frac{1}{2}$						
6						
$6\frac{1}{2}$						
7						

Use this bulletin as a worksheet. Complete the appropriate tables and plot the curve for the fan or fans you want to evaluate on the appropriate table and curves in this publication.

You should have little trouble following the suggested four-step procedure if you carefully follow the examples and have a calculator to do the arithmetic.

Step 1. For the fan or fans you wish to evaluate, enter the fan specifications in total airflow (cfm) vs. static pressure in inches of water in Column 1, Table 2. Space is provided to enter the airflow at each half-inch of water. Some manufacturers only provide the information for their fans for each inch, which is satisfactory for this evaluation although not as accurate or easy to plot. If you do not have the specifications for the fan you need to evaluate, contact a dealer for the bin fan to obtain the information. The example given in this bulletin is for one manufacturer's 10-hp vane axial or propeller fan. Space is provided for you to evaluate up to two fans. For example, you might want to evaluate a vane axial fan vs. a centrifugal fan, or one manufacturer's fan vs. another's.

The only accurate way for you to evaluate the performance of a bin drying fan is to evaluate a specific fan on a specific bin diameter and depth of corn.

Step 2. Calculate the air velocity in feet per minute (fpm) through the bin floor for your specific fan and bin by dividing the cfm at each static pressure by the bin floor area. Enter these figures in Column 2, Table 2. The floor area for several common bin diameters is given in Table 3. For other bin diameters, the floor area = bin diameter in feet x bin diameter in feet x 0.7854. A 27-foot-diameter bin with a floor area of 573 sq ft (27 ft x 27 ft x 0.7854) was selected as the example bin throughout this bulletin. For the example fan and bin at zero-inch static pressure, the airflow = 40.8 fpm $\left(\frac{23{,}400 \text{ cfm}}{573 \text{ sq ft}}\right)$.

Table 3. Typical grain bin characteristics

Common bin diameter	Floor area	Bin capacity
(ft)	(sq ft)	(bu/ft)
18	254	203
21	346	277
24	452	362
27	573	458
30	707	566
33	855	684
36	1,018	814
40	1,257	1,005
42	1,385	1,108
48	1,809	1,448
60	2,827	2,262

Step 3. Plot the air velocity (fpm) for each static pressure on the air velocity vs. static pressure curves (Fig. 1) as was done with the example 10-hp vane axial fan. Connect the dots. Although a smooth curve through the points is slightly more accurate, it is easier and sufficiently accurate to draw a straight line from point to point.

Step 4. From the curve you have drawn for your fan, determine the approximate depth of corn for the five specific airflow-per-bushel levels 1, $1\frac{1}{4}$, $1\frac{1}{2}$, 2, and 3 cfm bu. These are important airflows to evaluate fan performance for low-temperature drying as indicated in Table 1.

You must use judgment to complete this step. For instance, note that the curve for the example 27-foot bin equipped with the 10-hp fan crosses the 1 cfm/bu curve between the 18- and 20-foot corn depth curves, or about 19 feet as entered in Table 4.

Using the same type of judgment, complete Table 4 for your fan, as was done for the example bin and fan.

You now have the necessary information to judge or estimate the effectiveness for the bin fan or fans you evaluated to satisfactorily dry your corn with low-temperature drying techniques.

Although farmers are usually most interested in the airflow when the bin is full, it is necessary to estimate the airflow at various depths of fill for either layer or controlled filling, as discussed on pages 16 through 18 in MPWS-22.

For instance, what depth of corn, with a maximum moisture content of 20%, can be loaded on or after October 1 into the example bin equipped with the 10-hp vane axial fan and be safely dried?

Table 1 shows that corn with a maximum of 20% moisture, harvested on or before

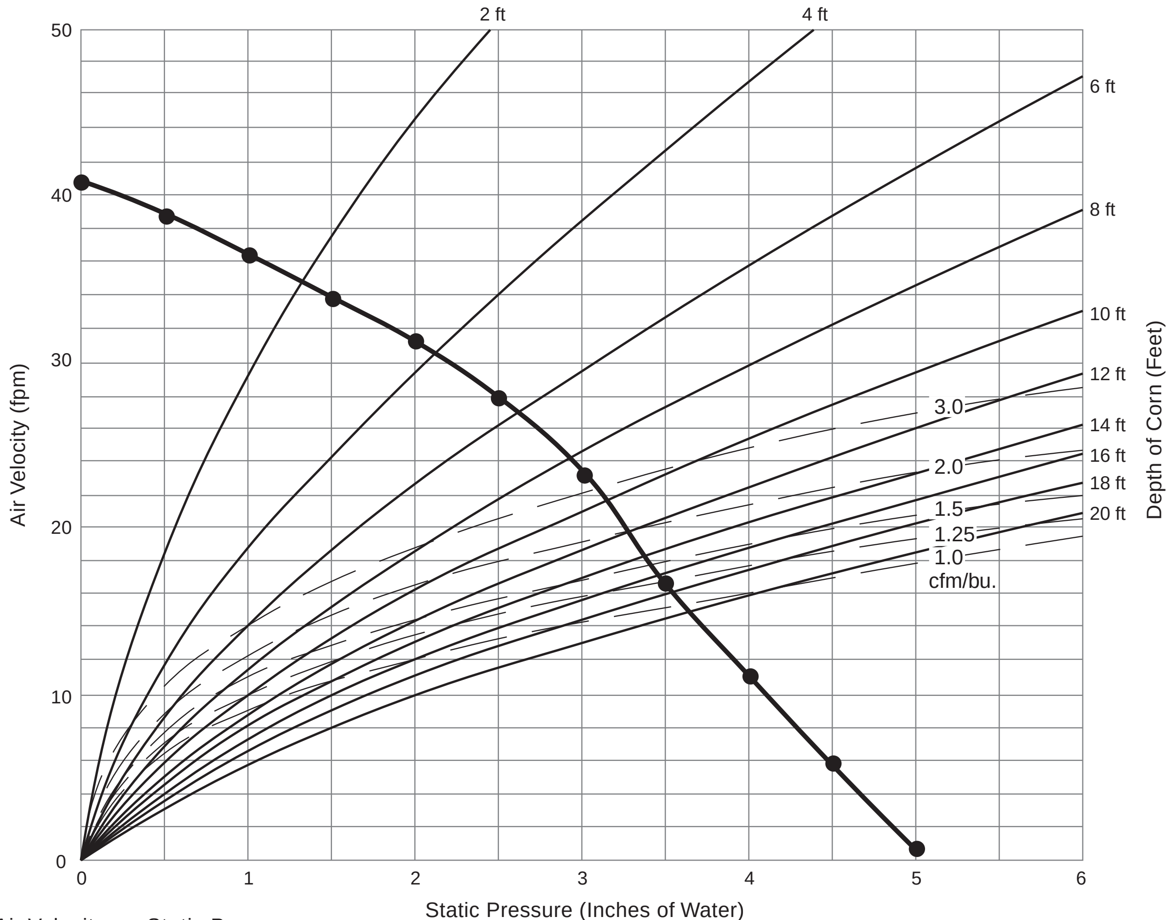

Fig. 1. Air Velocity vs. Static Pressure

Corn Depth (Feet)

Airflow per Bushel (cfm/bu)

Example Fan and Bin

October 1, needs a minimum of 1 cfm/bu, and Table 4 shows that the example bin and fan will deliver an estimated 1 cfm/bu through approximately 19 feet of corn. Therefore, we can conclude that up to a **maximum** depth of 19 feet of this corn can be loaded into the bin and safely dried since the airflow is at the minimum required.

High-Temperature Drying

You can also evaluate a fan or fans used for such purposes as high-temperature bin-batch or continuous-flow dryers where the airflow per bushel is considerably greater than 3 cfm/bu. The following is a suggested five-step procedure that is a modification of the previous four-step procedure.

1. Complete Steps 1 through 3 of the four-step procedure.
2. Find the air velocity for the desired depth of fill from Fig. 1.
3. Multiply the air velocity times the bin floor area to estimate total airflow in cfm.
4. Determine the bushels of corn to be dried by multiplying the desired depth of fill times the bushels of corn per foot given in Table 3.
5. To determine estimated airflow per bushel (cfm/bu), divide the total airflow by the bushels of corn.

Table 4. Estimated airflow-per-bushel summary.

Estimated airflow per bushel. Important for low-temperature drying	Example 27-ft-dia. bin with 10-hp fan. Approx. depth of fill	Your __-ft-dia. bin with __-hp fan. Approx. depth of fill	Your __-ft-dia. bin with __-hp fan. Approx. depth of fill
(cfm/bu)	(ft)	(ft)	(ft)
1	19		
1¼	17		
1½	15		
2	12		
3	9		

Determine the airflow per bushel for the example 27-foot-diameter bin equipped with the 10-hp fan used as a heated-air-bin dryer in which the corn would be maintained as close to the 6-foot level as possible.

1. This step has been completed. Fig. 1 is the result.
2. From Fig. 1, the air velocity for the example bin and fan at the 6-foot level is approximately 27 fpm.
3. Total estimated airflow = 27 fpm x 573 sq ft = 15,471 cfm.
4. Bushels of corn = 458 bu/ft x 6 ft = 2,748 bu.
5. Estimated airflow per bushel =

$$\frac{15{,}471 \text{ cfm}}{2{,}748 \text{ bu}} = 5.6 \text{ cfm/bu.}$$

Remember: the greater the airflow per bushel, the greater the drying capacity in bushels per hour. Heated-air bin dryers often have fans that will move close to 10 cfm per bushel.

Aeration and Hot Corn Cooling

The five-step procedure just described can also be used to estimate the airflow a specific fan will deliver to aerate a specific size of bin of dry corn

The primary limitation for this purpose is that Fig. 1 is not drawn to provide the best accuracy for smaller aeration fans. MWPS AED-20, “Managing Dry Grain in Storage,” available at your county extension office, describes how to estimate the cooling or warming time when the airflow per bushel is known.

The five-step procedure can be used to estimate the airflow per bushel through a bin used for cooling hot corn taken from a dryer by either bin cooling or dryeration techniques. Airflow per bushel must be known to determine the cooling time for the corn. The cooling time in hours is approximately equal to 15 divided by the airflow per bushel (cfm/bu). For instance, from the previous example, the fan would cool 6 feet of corn (2,748 bu) in approximately 2.7 hours ($\frac{15}{5.6 \text{ cfm/bu}}$).

The recommended airflow per bushel depends on numerous factors, such as the specific grain flow rates (bushels per hour or bushels per day) needed for loading and unloading for a cooling bin that will be compatible with heated-air-dryers with different drying capacities. Consequently, a complete, rather lengthy discussion about selecting a fan for cooling hot corn is not included in this publication.

If you desire additional assistance about selecting or using fans for any of the corn-conditioning practices discussed in this publication, contact a competent commercial drying bin representative or the Iowa State University county, area, or state extension staff. The five types of information they would need to know to help you are: the fan specifications as described in Table 2, bin diameter, depth of fill, type of grain, and a general description of your specific grain conditioning goals or needs.

The specific airflow-per-bushel estimates for a fan and bin combination you will obtain from using the procedures in this bulletin may vary slightly with estimates from other sources about the same fan and bin. The primary reason is because the depth of corn and cfm/bu curves in Fig. 1 were drawn by assuming a pack factor of 1.5. This figure is an estimate of the packing in the grain which depends on such variables as type of grain spreader, depth of fill, and amount of fines in the corn. Although not all persons competent in grain-drying technology use the same pack factor, most extension agricultural engineers in the Corn Belt states have agreed to use the 1.5 factor for estimating fan performance. Using this figure should give you an estimated airflow value that is at least equal to and probably less than the actual amount of air that is being delivered. It is to your advantage if your fan is delivering more air than you estimated.

Check Your Fan

It is desirable to check the airflow your fan is delivering to your bin at different depths of fill. The actual airflow can be checked by measuring the static pressure, in inches of water, below the perforated floor. The static pressure can be measured with either a commercial or homemade manometer. A manometer is basically a transparent tube fastened to a board in a “U” shape as shown in Fig. 2.

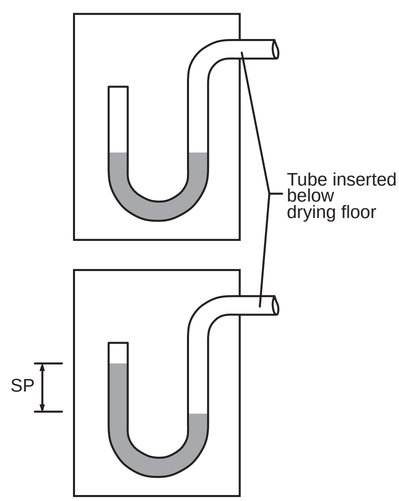

Fig. 2. Two manometers. The water is at the same level in both sides of the top manometer. The static pressure (SP) is zero inches, indicating the fan is not operating. When the fan is operating, as indicated in the bottom manometer, the water is pushed down in the right side and up in the left side. The distance SP between the two water levels is the static pressure measured in inches.

When you know the static pressure, the total airflow (cfm) can be estimated from the fan specifications (see Table 2). The actual airflow moving through the grain will likely be somewhat less than indicated by the static pressure-airflow curve because of air leaking out of the fan, transition piece, and bin, and also because the shape of the ductwork may cause the fan to deliver a lower airflow. You would be safer to assume the actual air moving through the grain is about 80 percent of that indicated from the fan spaces in Table 2.

The following is a brief description of how the actual airflow, as indicated by static pressure, can be used as a check of the estimated airflow procedures in this publication. Assume the example 10-hp vane axial fan was checked with the bottom manometer in Fig. 2 when operating in the 27-foot-diameter bin filled with 20 feet of corn. If the static pressure measured about $3\frac{1}{4}$ inches, it would indicate (from Fig. 1) the air velocity to be about 20 fpm. The total indicated airflow would be about 11,460 cfm (20 fpm x 573 sq ft). Assume the actual airflow moving through the grain will be 80% or 0.8 of the indicated airflow. Multiply the indicated airflow times 0.8 or 11,460 x 0.8 = 9,168 cfm.

Now, check the estimated airflow. Note in Fig. 1, the example bin and fan curve crosses the 20-foot depth of grain curve at about $3\frac{1}{2}$ inches. From Table 2, the indicated total airflow at $3\frac{1}{2}$ inches is 9,400 cfm. This compares closely to the check—9,400 cfm vs. 9,168 cfm.

Estimating the airflow by checking the static pressure should be more accurate than the procedures for estimating provided in this publication. As emphasized throughout this publication, these procedures are **estimates.**

Additional general information about static pressure and airflow are discussed on pages 9-11 in MWPS-22, “Low Temperature and Solar Grain Drying Handbook.”

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