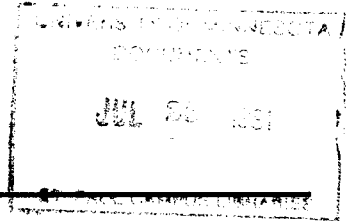


Selecting Fans and Determining Airflow for Crop Drying, Cooling, and Storage

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Using fans to force air having the proper temperature and relative humidity through a crop is a valuable technique for maintaining quality after harvest. The air helps maintain the moisture, temperature, and oxygen content of a crop at levels that prevent growth of harmful bacteria and fungi and excessive shrinkage.

This fact sheet provides information that will help you select new fans for crop drying, cooling, or storage facilities, or help you determine airflow delivered by existing fans. Grains and oilseeds are the primary crops discussed, but hay, potatoes, and other types of produce are also mentioned.

AIRFLOW REQUIREMENTS

Total airflow provided by a fan is usually expressed as cubic feet of air per minute (cfm). Recommendations for drying or aerating a particular crop are given as airflow per unit of crop being served by the fan. For example, cfm per bushel (cfm/bu) is used for drying or aerating grains and oilseeds. Typical airflow recommendations are listed in Table 1. Select fans that deliver airflow within the ranges given in the table: greater airflows require larger fans and lead to greater costs, while lower airflows could result in unacceptable crop quality.

AIRFLOW RESISTANCE

Crops

When air is forced through a bulk crop, it must travel through narrow paths between individual particles. For packaged crops, air must travel through or between individual containers. Friction along air paths creates resistance to airflow. Fans must develop enough pressure to overcome this resistance and move air through the crop.

Airflow resistance and fan pressure are usually expressed in inches of water column (in. water, or in. H₂O). This term comes from gages called u-tube manometers that are sometimes used to measure pressure (Figure 1). You can make a u-tube manometer by fastening a clear plastic tube and a ruler to a board. Then pour some water, or water plus a small amount of antifreeze, into the tube. Since manometers are used to measure pressure relative to atmospheric pressure, leave one end of the tube open to the atmosphere. Attach the other end to the duct or plenum where you want to measure pressure.

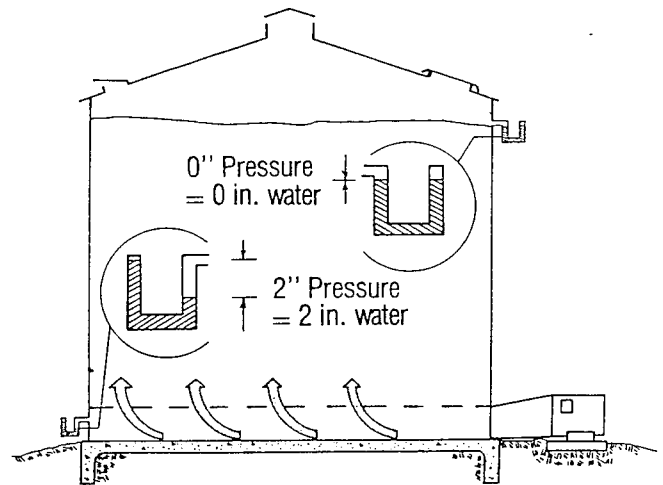


Figure 1. Using a u-tube manometer to measure pressure in a grain bin

When a fan generates pressure, it forces water in the tube to move in the direction of lower pressure. The height difference of the water levels on the two sides of the tube, measured in inches, is the fan static pressure, in. water. In negative pressure or suction systems, pressure between the crop and the fan is less than atmospheric pressure and water in the manometer tube moves toward the fan. In positive pressure systems, water moves away from the fan. You can buy dial-type pressure gages that operate on a different principle but that are calibrated to give readings in in. water.

The airflow resistance of a crop and the fan pressure required to overcome it depend on how fast the air is moving and how long and narrow the paths are. For grains and oilseeds, these factors are a function of the particular crop (size and shape of seeds), crop depth, and airflow rate (cfm/bu) you're trying to provide.

As you can see from Tables 2 through 6, at a given airflow rate, crop depth has a large effect on static pressure. Static pressure, in turn, greatly affects fan power requirements. Short, large diameter bins are recommended for natural-air grain drying because static pressure and required fan size are smaller than they would be in tall, narrow bins. Even though short bins cost more to install than tall ones that have the same grain capacity, total drying costs are less because smaller fans use less electricity.

Airflow resistance of hay, potatoes, and other produce also depends on crop depth or thickness of the layer to be ventilated and airflow rate. For packaged produce, the type of container and the way containers are stacked can also make a difference. But in most cases, airflow resistance of these crops seldom requires fan pressure greater than about 1 in. water. So, if better information is lacking, use 1 in. as a static pressure estimate for these crops.

Floors and ducts

The full perforated floors used in grain bins generally have negligible resistance to airflow. Airflow resistance of bin floors isn't significant unless open area is less than about 7%; most commercially available floors have more than 10% open area.

Air supply ducts, tunnels, and perforated air distribution ducts offer greater resistance to airflow than do full perforated floors. This resistance can be quite large if ducts are too small or too long. Use ducts that are large enough that air velocity is less than about 1500 feet per minute. (Divide duct airflow in cfm by duct cross sectional area in square feet to get velocity.) Also, try to keep duct length less than 100 ft. Unless you have better information, use 0.5 in. water as an estimate of airflow resistance for duct systems. Be aware that corrugated plastic ducts designed for air distribution have only 1 to 3% open area, and ordinary plastic tile designed for field drainage has less than 1% open area. Because plastic ducts have so little area for air exit, their airflow resistance can exceed 0.5 in. water.

Air inlet and exhaust openings

When outdoor air is used to ventilate a bin or building, you need to provide adequately-sized openings for air to move in and out of the structure. If openings are too small, they restrict airflow and increase fan pressure requirements. Provide at least one square foot of inlet area per 1000 cfm and an equal exhaust area, and make sure these vents or doors are open anytime the fan is operating.

FAN PERFORMANCE

Because of the way fan impellers (blades or rotors) are designed, the amount of air they can move decreases as the pressure they are working against increases. The airflow vs. pressure information for a particular fan is called the fan performance data. Performance depends on the size, shape, and speed of the impeller, and the size of the motor driving it. Performance differs widely among brands and models, even for fans with the same size motor.

Access to fan performance data is essential for selecting fans and for determining airflow provided by existing fans. Most manufacturers sell fans that have been tested using procedures specified by the Air Movement and Control Association (AMCA). The manufacturers can provide you with performance data in the form of tables or graphs. Avoid fans for which AMCA data is not available. Table 7 is an example of the type of data you need. Figure 2 is a graphical presentation of the data for two fans from Table 7 that have the same size motor. Notice how much performance of the two fans differs.

FAN TYPES

Most fans can be categorized as either axial-flow or centrifugal (see Figure 4). Axial-flow fans are sometimes called propeller fans, although that's really just one type of axial-flow fan. Air moves in a straight line through axial-flow fans parallel to the axis or impeller shaft. The impeller has a number of blades attached to a central hub.

Centrifugal fans are sometimes called blowers or squirrel cage fans. The impeller is a wheel that consists of two rings with a number of blades attached between them. Air enters one or both ends of the impeller parallel to the shaft and exits one side perpendicular to the shaft. The blades can be straight, slanted in the direction of airflow (forward-curved), or slanted opposite the airflow direction (backward-curved or backward-inclined).

Propeller fans (panel fans)

These are axial-flow type fans that have from 2 to about 7 long blades attached to a small hub. Fan diameter is usually large relative to the fan's length or thickness. Some propeller fans are called panel fans and are designed for mounting in a wall or plenum divider. Some are belt-driven and some have the impeller hub attached directly to the motor shaft (direct-driven).

Propeller fans normally can't generate more than about 2 in. water pressure. They are most commonly used for potato ventilation, forced-air produce cooling, hay drying, exhausting air from attics or overhead spaces, or general air circulation. They are seldom used for grain drying or aeration.

Tube-axial, vane-axial

These axial-flow fans have a barrel-shaped housing and an impeller that has a large hub with a number of short blades attached to it. They are generally direct-driven and the motor is cooled by the air stream. In positive pressure systems, the air stream captures the waste heat given off by the motor. Vane-axial fans have guide vanes inside the fan housing to help reduce air turbulence.

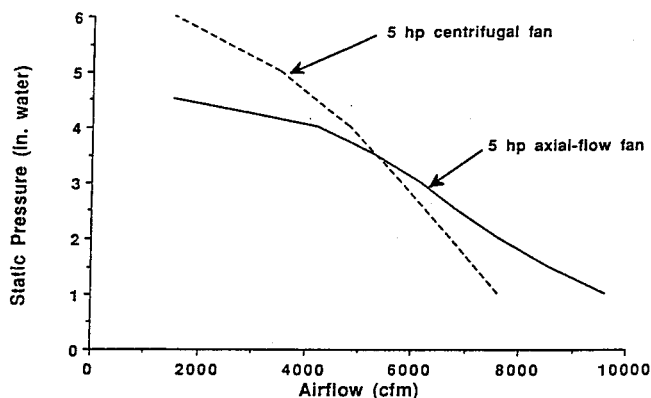


Figure 2. Fan performance data for MES Fans #7 and #10 from Table 7.

Tube-axial and vane-axial fans are the most common types used for grain drying and aeration. They are relatively inexpensive and fairly efficient when static pressure is less than about 4 in. water. The main disadvantage of these fans is that they are very noisy.

Centrifugal

The centrifugal fans used for crop drying and storage generally have backward-curved or backward-inclined blades. They are expensive, but are also quiet and are usually the most efficient type of fan when static pressure is greater than about 4 in. water. The motor on centrifugal fans is normally outside the air stream; you need to install a special housing around the motor if you want to capture the heat it gives off.

Forced-air heating and ventilating systems often use centrifugal fans that have forward-curved blades. Motors on these fans can be overloaded and burn out when the fans are operated outside certain pressure ranges. This characteristic makes them unsuitable for many crop drying and storage applications.

In-line centrifugal

These fans have axial airflow, but use a centrifugal-type impeller. Price and operating characteristics are between those of backward-inclined centrifugal and tube-axial fans.

MULTIPLE FANS

It is sometimes necessary or desirable to install more than one fan to provide air to a common plenum or supply manifold for a duct system. Fans can be arranged in parallel or series (Figure 3). Reasons for using multiple fans include:

- Total airflow, pressure, or power requirements exceed the capabilities of the largest fan available from your dealer.
- The starting current for a single large fan motor is greater than the electrical system can handle. The maximum starting current is lower if several small fans are started one at a time.
- When multiple fans are installed, you have the option of turning some of the fans off and operating with a lower airflow when conditions allow.
- Air distribution is sometimes more uniform when several small fans are used in place of one large one.

Parallel

Parallel arrangement means fans are installed side-by-side or at several points along a manifold or plenum. The most common applications are where total airflow requirement is large, but pressure is moderate. When fans are installed in parallel, they all face the same pressure. Total airflow is estimated by adding the airflow provided by each fan at the expected pressure.

Series

Series arrangement, where fans are fastened in line or end-to-end, is not used very often. When it is used, it generally involves tube-axial or vane-axial fans in situations where pressure is relatively high, such as in deep grain bins. Series arrangement

is seldom used with centrifugal fans and seldom are more than two axial-flow fans connected in series. When fans are arranged in series, each fan handles the same airflow. Total pressure is estimated by adding the pressure developed by each fan at the expected airflow.

DETERMINING AIRFLOW PROVIDED BY EXISTING FANS

Knowledge of the airflow that a fan is providing allows you to estimate the time it will take to dry or cool a crop. This in turn, helps you determine whether steps need to be taken to prevent unacceptable quality loss before the task is completed.

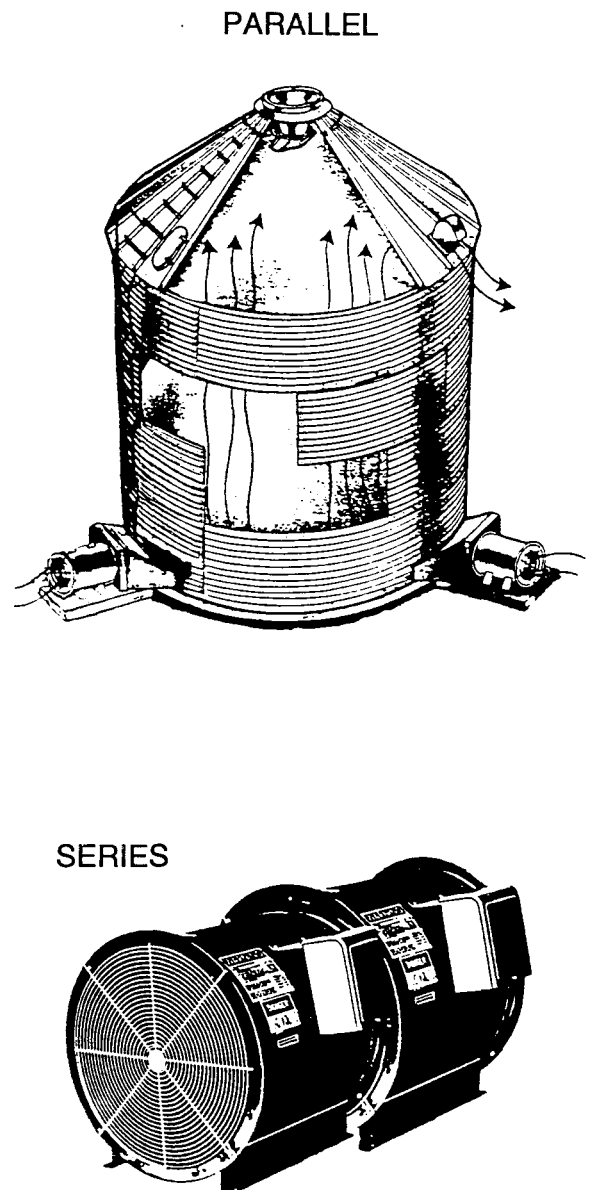


Figure 3. Parallel and series fan arrangement.

The first step in determining airflow is to measure static pressure in the duct or plenum between the fan and the crop (Figure 1). Drill a small hole (1/8 in. should be adequate) in the wall of the duct or plenum and press a tube from one side of a pressure gage or u-tube manometer against the hole. Then, take the pressure reading and use its absolute value (this means assume the reading is positive even if it's a negative pressure system) to determine the airflow. Use the AMCA performance data for that model fan at that pressure. To get airflow rate (cfm/bu, for example), divide the airflow from the performance table or graph by the amount of crop being served by the fan.

For example, suppose fan #4 from Table 7 is being used to dry 10 tons of hay and the static pressure reading in the duct to which the fan is attached is 1.0 in. water. The fan performance data in Table 7 shows that fan #4 provides 2775 cfm against a pressure of 1 in. Airflow per ton is $2775 \text{ cfm} \div 10 \text{ tons} = \text{about } 278 \text{ cfm/ton}$. This value is within the recommended range for hay drying given in Table 1.

Because airflow resistance and static pressure vary with type of crop, crop depth, amount of fines present, and the way the crop is piled, you need to repeat the above procedure and determine a new airflow anytime conditions change.

SELECTING FANS

Calculate total airflow needed

The first step in selecting a fan is to determine the total airflow it must provide. You can use the airflow rates in Table 1 as a guide. Choose an airflow rate, estimate the total quantity of crop to be served by the fan, and then multiply the airflow rate by crop quantity to get total airflow requirement.

For example, if you want to supply 1 cfm/bu to natural-air dry corn in a 27-ft diameter by 16 ft deep bin that has a full perforated floor,

$$\begin{aligned} \text{Bin capacity} &= \pi \div 4 \times (\text{diameter})^2 \times \text{depth} \times 0.8 \text{ bu/cubic ft} \\ &= 0.785 \times 27 \text{ ft} \times 27 \text{ ft} \times 16 \text{ ft} \times 0.8 \text{ bu/cubic ft} \\ &= 7325 \text{ bu} \end{aligned}$$

$$\text{Total airflow} = 1 \text{ cfm/bu} \times 7325 \text{ bu} = \underline{7325 \text{ cfm}}$$

Estimate static pressure

The next step in selecting a fan is to estimate the pressure the fan will be operating against. For grains and oilseeds, use the desired airflow rate and expected crop depth and read the appropriate pressure value from Tables 2 through 6. Remember to add 0.5 in. to the value from the table if air is distributed through a duct system. For hay, potatoes, or other produce, use 1 in. water as a pressure estimate unless a better number is available.

Continuing our example, Table 3 indicates that the expected pressure for 16 ft of corn and an airflow rate of 1 cfm/bu is 2.4 in. water.

Estimating fan power requirements

Fans are usually described by the horsepower (hp) rating of the motor used to drive the impeller. It's helpful when selecting fans

to estimate the power requirement first so you know where to start looking in the manufacturer's catalog.

Fan motor size depends on the total airflow being delivered, the pressure developed, and the impeller's efficiency. Impeller efficiencies generally range from 40% to 60%. If we assume an average value of 50%, we can use the following formula to estimate the fan power requirement.

$$\text{Fan power (hp)} = \text{airflow (cfm)} \times \text{static pressure (in. water)} \div 3178$$

In our example,

$$\text{Fan power} = 7325 \text{ cfm} \times 2.4 \text{ in. water} \div 3178 = \underline{5.5 \text{ hp.}}$$

Selecting the best fan available

Purchase cost and noise during operation can be important factors in selecting a fan, but the most critical factor is whether the fan can provide enough airflow at the expected operating pressure. Start by looking at performance data for a fan having a motor rated just under the power value you calculated. If this fan provides more than enough airflow, look at the next size smaller. If your first pick is too small, try the next size larger.

If we use the list of fans in Table 7 to select a fan for our example problem, we see that fan #7 (a 5.0-hp axial flow fan) comes closest to meeting our needs. Fans #6 and #10 wouldn't provide enough airflow at 2.4 in. water and fans #8 and #11 would provide much more airflow than is needed.

Sometimes fans produced by one manufacturer won't meet your needs and you'll have to look at another manufacturer's fans. Or, if you are having trouble finding a fan that is big enough, you might consider using several smaller fans. (See the section on multiple fans.)

Computerized fan selection

The fan selection procedure that was just described is not too difficult, but there is an easier way to select fans for grain bins. You can use the FANS2 computer program available from the University of Minnesota Agricultural Engineering Department and some county extension offices. The program is very user friendly and guides you through the fan selection process by asking some simple questions about your grain drying or storage bin. The program allows you to select fans from a list of over 200 commercially available models and see if the selected models provide the desired airflow.

SUMMARY

Selection of proper fans and determination of actual airflow provided by existing fans are important steps in preserving quality of crops after harvest. Make sure you have fans that provide enough airflow to dry or cool crops before unacceptable quality loss occurs.

FOR MORE INFORMATION...

Contact your local extension office for more information on selecting fans or managing crops after harvest.

Table 1. Airflow recommendations for drying, cooling, and storing crops

Natural-air drying of grains and oilseeds	0.75 to 1.5 cfm/bu
Aeration of stored dry grains and oilseeds	0.05 to 0.5 cfm/bu
Hay drying	150 to 500 cfm/ton
Potato ventilation (airflow per hundredweight)	0.5 to 1.5 cfm/cwt
Forced-air produce cooling	1 to 10 cfm/lb

Table 2. Airflow resistance data for barley and oats.

Values in the table have been multiplied by 1.5 to account for fines and packing in the bin. Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain depth (ft)	Airflow (cfm/bu)								
	0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.5
6	0.1	0.1	0.1	0.2	0.4	0.5	0.7	0.8	1.1
8	0.1	0.1	0.2	0.4	0.7	0.9	1.2	1.5	2.1
10	0.1	0.1	0.3	0.7	1.1	1.5	2.0	2.5	3.6
12	0.1	0.2	0.5	1.0	1.6	2.3	3.0	3.7	5.4
14	0.1	0.3	0.7	1.4	2.2	3.2	4.2	5.3	7.8
16	0.2	0.3	0.9	1.9	3.0	4.3	5.7	7.2	10.6
18	0.2	0.4	1.1	2.4	3.9	5.6	7.5	9.5	14.1
20	0.3	0.5	1.4	3.0	4.9	7.1	9.5	12.2	18.1
25	0.4	0.8	2.2	4.9	8.2	11.9	16.1	20.7	31.1
30	0.6	1.2	3.2	7.4	12.4	18.3	24.8	32.1	48.7
40	1.0	2.1	6.0	14.2	24.4	36.2	49.8	*	*
50	1.6	3.4	9.9	23.8	41.4	*	*	*	*

* Static pressure is excessive--greater than 50 in. water.

Table 3. Airflow resistance data for shelled corn.

Values in the table have been multiplied by 1.5 to account for fines and packing in the bin. (If corn is stirred, which tends to decrease airflow resistance, divide table values by 1.5.) Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain depth (ft)	Airflow (cfm/bu)								
	0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2	0.2
6	0.1	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.6
8	0.1	0.1	0.1	0.2	0.3	0.5	0.6	0.8	1.2
10	0.1	0.1	0.2	0.3	0.5	0.8	1.1	1.4	2.0
12	0.1	0.1	0.2	0.5	0.8	1.2	1.6	2.1	3.2
14	0.1	0.1	0.3	0.7	1.2	1.7	2.3	3.0	4.6
16	0.1	0.1	0.4	0.9	1.6	2.4	3.2	4.2	6.4
18	0.1	0.2	0.5	1.2	2.1	3.1	4.3	5.6	8.7
20	0.1	0.2	0.7	1.6	2.7	4.0	5.6	7.3	11.3
25	0.2	0.4	1.1	2.6	4.6	7.0	9.7	12.8	19.9
30	0.3	0.5	1.6	4.1	7.2	11.0	15.3	20.3	31.9
40	0.5	1.0	3.1	8.1	14.6	22.6	31.9	42.5	*
50	0.7	1.6	5.3	14.0	25.6	39.9	*	*	*

* Static pressure is excessive--greater than 50 in. water.

Table 4. Airflow resistance data for soybeans and confectionary sunflowers.

Values in the table have been multiplied by 1.5 to account for fines and packing in the bin. Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain depth (ft)	Airflow (cfm/bu)								
	0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
6	0.1	0.1	0.1	0.1	0.2	0.2	0.3	0.3	0.5
8	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.9
10	0.1	0.1	0.1	0.3	0.4	0.6	0.8	1.0	1.5
12	0.1	0.1	0.2	0.4	0.7	0.9	1.2	1.6	2.3
14	0.1	0.1	0.3	0.6	0.9	1.3	1.7	2.2	3.3
16	0.1	0.1	0.3	0.8	1.2	1.8	2.4	3.0	4.5
18	0.1	0.2	0.4	1.0	1.6	2.3	3.1	4.0	6.0
20	0.1	0.2	0.6	1.2	2.0	3.0	4.0	5.1	7.7
25	0.2	0.3	0.9	2.0	3.4	5.0	6.8	8.8	13.4
30	0.2	0.5	1.3	3.1	5.2	7.7	10.6	13.7	21.0
40	0.4	0.9	2.5	5.9	10.3	15.4	21.4	28.0	43.4
50	0.6	1.4	4.1	10.0	17.6	26.7	37.2	49.1	*

* Static pressure is excessive--greater than 50 in. water.

Table 5. Airflow resistance data for oil-type sunflowers.

Values in the table have been multiplied by 1.5 to account for fines and packing in the bin. Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain depth (ft)	Airflow (cfm/bu)								
	0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
4	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.2	0.3
6	0.1	0.1	0.1	0.2	0.3	0.4	0.5	0.6	0.9
8	0.1	0.1	0.1	0.3	0.5	0.7	0.9	1.1	1.7
10	0.1	0.1	0.2	0.5	0.8	1.1	1.5	1.9	2.8
12	0.1	0.1	0.3	0.7	1.2	1.7	2.3	2.9	4.4
14	0.1	0.2	0.5	1.0	1.7	2.4	3.3	4.2	6.4
16	0.1	0.2	0.6	1.4	2.3	3.3	4.5	5.8	8.8
18	0.1	0.3	0.8	1.8	3.0	4.4	6.0	7.8	11.8
20	0.2	0.3	1.0	2.3	3.8	5.6	7.7	10.0	15.3
25	0.3	0.6	1.6	3.7	6.5	9.7	13.3	17.4	26.9
30	0.4	0.8	2.4	5.7	10.0	15.1	20.9	27.5	42.7
40	0.7	1.5	4.5	11.3	20.1	30.7	43.0	*	*
50	1.1	2.4	7.5	19.3	34.8	*	*	*	*

* Static pressure is excessive--greater than 50 in. water.

Table 6. Airflow resistance data for wheat and sorghum.

Values in the table have been multiplied by 1.3 for wheat and 1.5 for sorghum to account for fines and packing in the bin. Add 0.5 in. water to the table values if air is distributed through a duct system.

Grain depth (ft)	Airflow (cfm/bu)								
	0.05	0.1	0.25	0.5	0.75	1.0	1.25	1.5	2.0
	Expected static pressure (inches of water)								
2	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.2
4	0.1	0.1	0.1	0.2	0.3	0.3	0.4	0.5	0.7
6	0.1	0.1	0.2	0.4	0.6	0.8	1.0	1.2	1.7
8	0.1	0.1	0.3	0.7	1.1	1.5	1.9	2.3	3.2
10	0.1	0.2	0.5	1.1	1.7	2.3	3.0	3.7	5.3
12	0.1	0.3	0.8	1.6	2.5	3.4	4.5	5.6	7.9
14	0.2	0.4	1.0	2.2	3.4	4.8	6.3	7.8	11.3
16	0.3	0.5	1.4	2.9	4.6	6.4	8.4	10.6	15.3
18	0.3	0.7	1.7	3.7	5.9	8.3	11.0	13.8	20.0
20	0.4	0.8	2.2	4.7	7.5	10.5	13.9	17.6	25.6
25	0.6	1.3	3.4	7.5	12.2	17.4	23.1	29.4	43.3
30	0.9	1.9	5.1	11.2	18.3	26.3	35.3	45.0	*
40	1.7	3.4	9.3	21.1	35.1	*	*	*	*
50	2.6	5.4	15.0	34.8	*	*	*	*	*

* Static pressure is excessive--greater than 50 in. water.

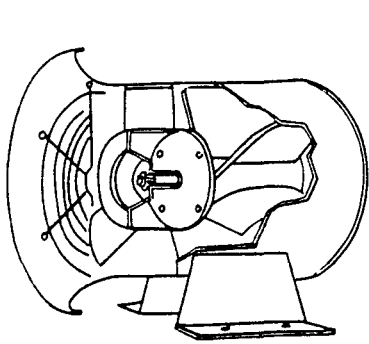
Table 7. Example of fan performance data.

This data is provided as an illustration only; these fans are not commercially available.

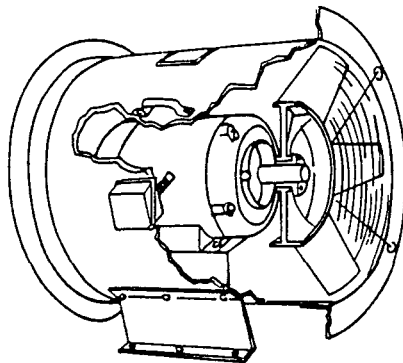
Fan #	Hp	Cubic feet per minute (cfm) at indicated static pressure (inches of water)												
		1.0	1.5	2.0	2.5	3.0	3.5	4.0	4.5	5.0	5.5	6.0	6.5	7.0
Fans 1 through 9 are axial-flow fans														
1	0.33	1,435	620	290										
2	0.5	1,880	960	800	620	380								
3	0.75	1,690	1,460	1,170	780									
4	1.0	2,775	2,500	2,075	1,150	775	500	260						
5	1.5	3,675	3,475	3,275	3,000	2,425	1,700	1,375						
6	3.0	6,400	5,700	5,200	4,500	3,700	2,900	2,200						
7	5.0	9,600	8,550	7,600	6,800	6,150	5,300	4,200	1,550					
8	7.5	13,400	12,500	11,500	10,400	9,000	7,500	6,200	4,450	2,250	1,350	650		
9	10.0	15,700	15,000	14,200	13,400	12,600	11,600	10,500						
Fans 10 through 14 are centrifugal fans														
10	5.0	7,600		6,700		5,800		4,800		3,500		1,500		
11	7.5	9,600		8,900		8,000		7,200		6,100		5,000		
12	10.0	13,450		12,720		11,960		11,120		10,180		9,040		7,450
13	15.0	16,000		15,100		14,200		13,100		11,800		10,000		
14	20.0	21,725		20,430		19,140		17,750		16,140		14,120		11,360

Figure 4. Types of fans used for ventilating crops.

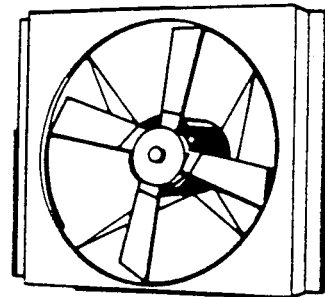
AXIAL-FLOW FANS



Vane-axial

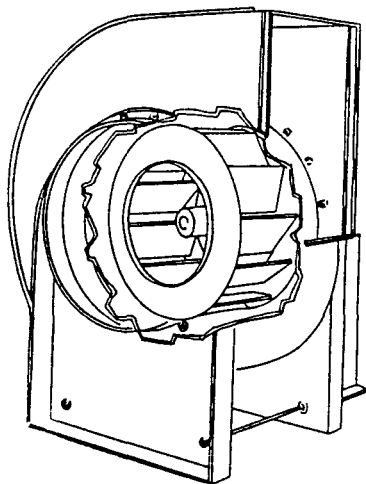


Tube-axial

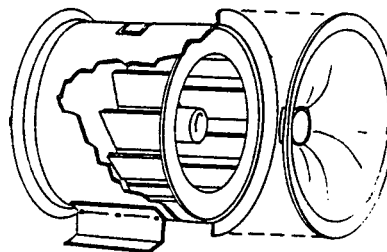


Propeller

CENTRIFUGAL FANS



Backward-inclined centrifugal



In-line centrifugal

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