

Selecting Ventilating Equipment for Animal and Poultry Houses

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Ventilation is required by livestock and poultry to control temperatures, control odor or gas or control moisture. Often, animal housing construction can provide natural ventilation by wind movement most of the year. However, if severe stress or bird or animal loss could occur without proper ventilation, the installation and use of powered ventilation equipment is feasible.

Fan Types

The right investment in ventilating equipment can save many dollars. Be aware of the fan alternatives as well as conditions under which they will operate. Fans are classified according to their application. Major groups are ventilating fans, mechanical draft fans, industrial exhausters and pressure blowers.

Ventilating fans are designed for general service at normal temperatures in relatively clean air. Heavy duty fans are used in severe conditions. Figure 1 shows common types of ventilating fans, including the axial and centrifugal designs. Axial fans are normally less expensive than the centrifugal type and are used for operation against static pressures of $\frac{1}{4}$ inch (water column) or less.

Although centrifugal fans can be used for low pressure general ventilation, usually they are used when air distribution duct systems are necessary, or for special applications such as evaporative coolers or roof exhausters. The

centrifugal fan provides quieter operation than most direct drive propeller fans.

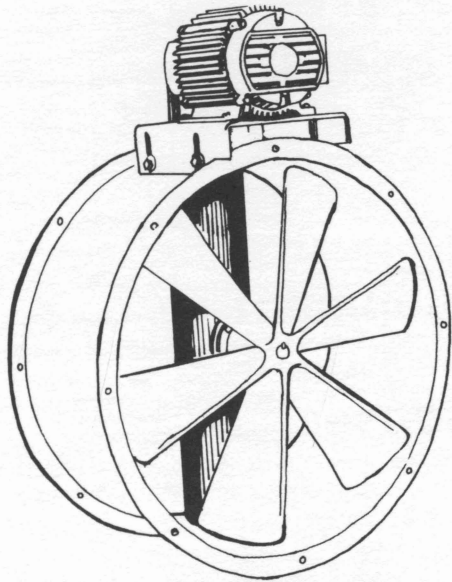
Fans may be direct drive or belt drive type. Direct drive fans are limited to speeds determined by motor design. They may be single speed or provide several motor speeds. The belt drive provides a wider range of operating speeds and capacities to fit specific needs. However, the use of belts involves more maintenance as well as additional energy loss caused by belt slip.

Fan Performance

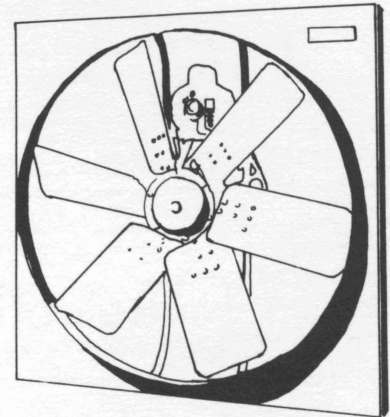
Ventilating equipment moves air under fixed conditions. The operating conditions, as well as fan design, determine the amount of air the unit will move and the motor horsepower required. Fans can be adapted to a range of conditions and air flow rates by varying such things as speed and operating pressure. The manufacturer usually defines these characteristics with fan curves (Figure 2) or fan selection tables (Table 1).

The intersection of the static pressure line with the SP versus cubic feet per minute curve will indicate the volume of air flow provided. For example, with 0.125 inches water column, the air flow will be 11,700 ft.³/min. Projecting this ft.³/min line up to the intersection of the brake horsepower versus ft.³/min. curve shows that the motor horsepower required will be 0.81. This indicates that a three-quarter horsepower motor can be used. With a 70 percent efficient motor, this fan will provide 14.6 ft.³/min. per watt of electrical input.

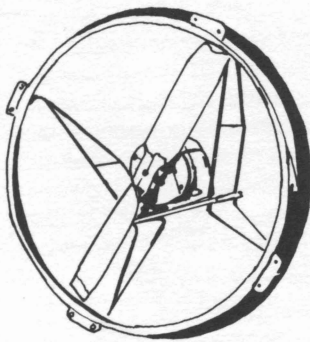
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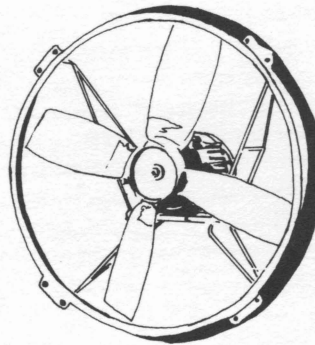
**Tube axial Duct Fan
Belted Drive**



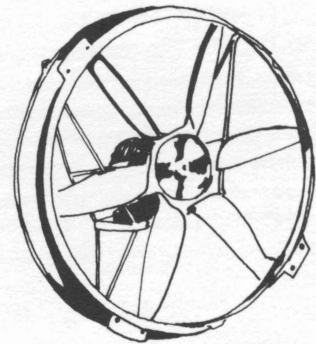
**Axial Flow Multiblade Fan
Belted Drive**



Single-Propeller Fan

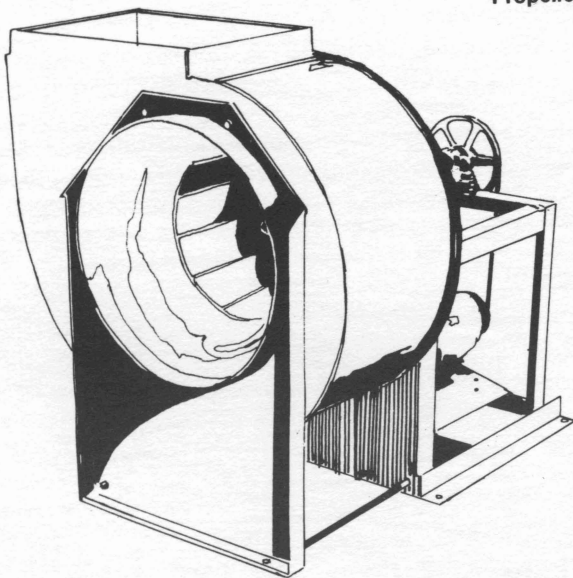


Four-Blade Fan

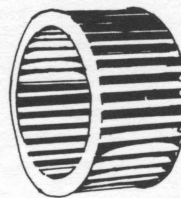


Multiblade Fan

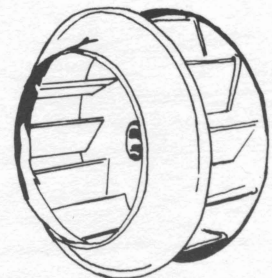
Propeller Type—Direct Drive



**Squirrel-Cage Blower
Belted Drive**



Forward Curve Wheel



Backward Inclined Wheel

Figure 1. Fan Types

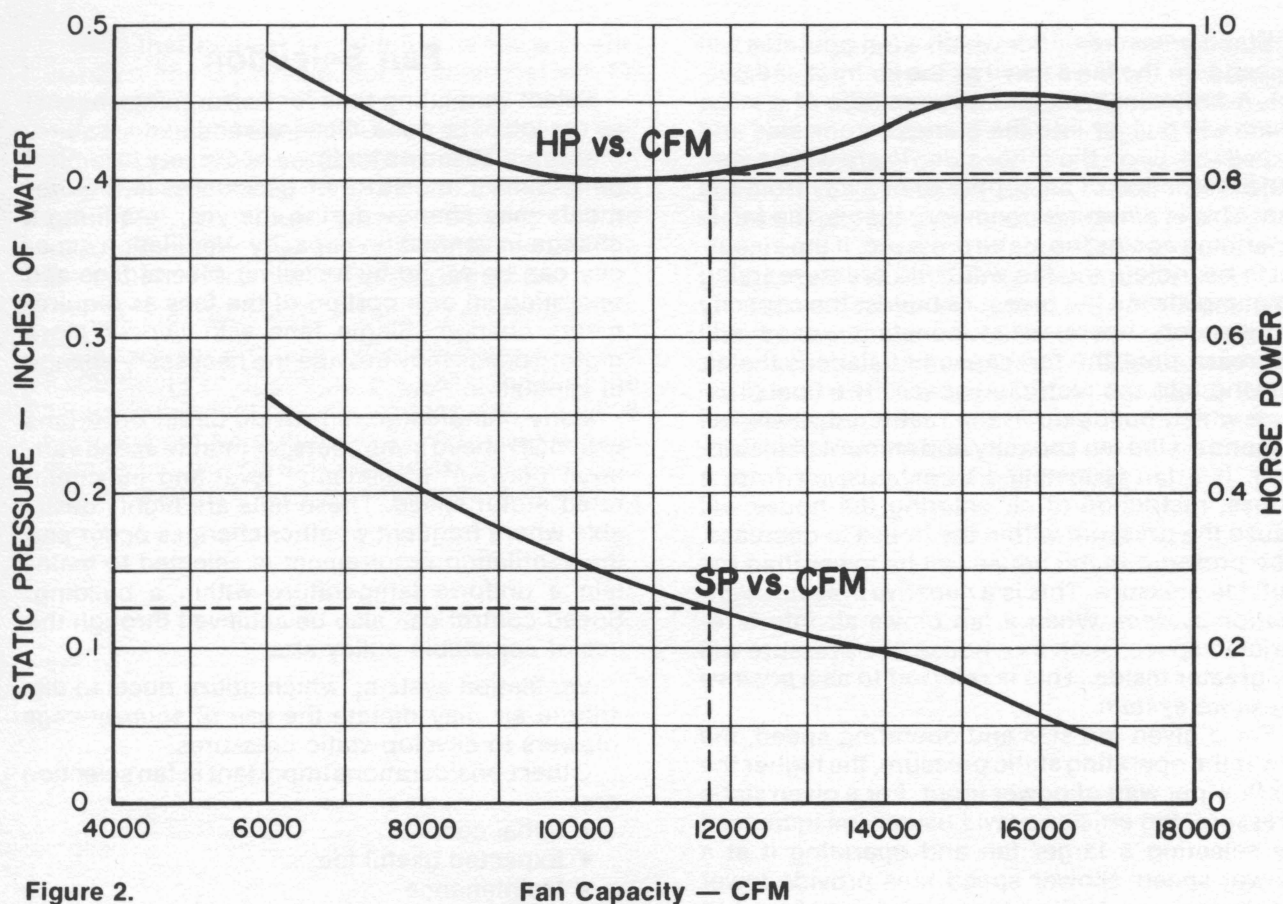


Figure 2.

Table 1. Typical Fan Table for a Nominal 48-inch Fan

		Fan Capacity ft ³ /min.						
Maximum Motor Horsepower	Rpm	0"sp	1/10"sp	1/8"sp	1/4"sp	3/8"sp	1/2"sp	BHP
1	340	22,410	20,150	19,250	9,700			1.29
1½	390	25,720	24,000	23,400	16,750			1.93
2	428	28,250	26,900	26,350	21,500	12,580		2.53
3	490	32,300	31,200	30,850	28,050	22,700		3.79
5	580	38,270	37,740	37,450	35,600	32,500	28,400	6.32

Other manufacturers may provide fan selection tables. Table 1 shows a typical fan table for a nominal 48-inch fan.

In this table, the actual horsepower required for a particular fan speed and static pressure is not shown. For example, if the fan is to operate at ½ inch static pressure and air flow of 26,000 ft³/min. is required, the fan would need to operate at about 428 rpm. The table indicates a motor horsepower requirement of two. Note that the fan rating table shows the same horsepower require-

ment for all static pressure levels and air flow rates shown at a particular fan speed (rpm). The motor horsepower is selected for the maximum requirement within this group. Under some static pressure conditions, a motor may not operate at full load, thus reducing motor efficiency. Try to operate an electric motor at its full rated load. Fan curves (Figure 2) better indicate the effect changes in static pressure have on motor horsepower requirements.

Static pressure under which a fan operates will depend on the fan as well as the air inlet and outlet. A propeller type fan in the middle of a large room will pull air into the blades on one side and expell the air on the other side. There will be very little restriction of air supply to or away from the fan. This is a *free-air condition*, that is, the fan is operating against no static pressure. If the air outlet is restricted, the fan will build pressure trying to pump air. As the pressure builds, the capacity of the fan operated at constant speed will decrease until the fan capacity balances the air moving into the restricted space. The final pressure which builds up in the restricted space will depend on the fan capacity and amount of restriction. If a fan is installed to exhaust air from a house, restriction of air entering the house will cause the pressure within the house to decrease. The pressure in the house will be lower than the outside pressure. This is a *negative pressure ventilation system*. When a fan blows air into a restricted space, such as a house, the pressure will be greater inside. This is referred to as a *positive pressure system*.

For a given fan size and operating speed, the lower the operating static pressure, the higher the air flow per watt of power input. For a given static pressure, fan efficiency will usually be increased by selecting a larger fan and operating it at a slower speed. Slower speed fans provide lower discharge air velocities than high speed fans, but there are some situations where the volume (cubic feet per minute) of air flow is not so important as the air velocity (feet per minute). In that case, one may need to choose smaller, higher speed fans to do a job.

If operating static pressure can be kept at $\frac{1}{8}$ inch (water column) or below, operating costs can be relatively low. As a general guide, an air inlet or outlet should have an area of about 1 square foot for each 500 to 800 cubic feet per minute of fan capacity. Automatic louvers at the outlet will increase the pressure. Where they are used, double the area to 2 square feet per 500 cubic feet per minute. Motorized louvers will reduce fan operating pressures. Curtain wall inlets where average velocity is no more than about 800 feet per minute should provide static pressures of 0.1 inch or below.

Evaporative cooling pads should have an area of 1 square foot for each 150 to 200 cubic feet per minute to limit static pressure drop across the pad. This low air flow rate will also increase cooling effectiveness of an evaporative system.

In general, for a fixed opening the static pressure will vary as the square of the ratio of the air flows. Thus, if the static pressure is .05 inch for an air flow of 1,000 cubic feet per minute and you double the air flow to 2,000 cubic feet per minute, the static pressure will increase to about 0.2 inch.

Fan Selection

Select ventilating fans for performance as well as the job to be done. General ventilation requirements are based on air flows necessary to control temperature, moisture or gases. These requirements may change during the year, requiring a change in ventilation capacity. Ventilation capacity can be varied by installing several fans and operating all or a portion of the fans as requirements change. Single fans with two or more motor speeds may provide the necessary change in ventilation rate.

Many manufacturers provide direct drive fans with SCR speed controllers for infinite speed variation between a minimum level and maximum rated motor speed. These fans are highly desirable where frequent weather changes occur and the ventilation requirement is selected to maintain a uniform temperature within a building. Speed control can also be achieved through the use of adjustable pulley size.

Ventilation systems which utilize ducts to distribute air may dictate the use of squirrel-cage blowers to develop static pressures.

Other considerations important in fan selection are:

- Initial cost
- Expected useful life
- Maintenance
- Operating cost

Energy Use and Efficiency

When two or more fan selections can do a ventilation job, consider the economics of each alternative. Total owning and operating expense includes initial cost, interest on investment, maintenance and operating cost. Operating cost is affected by energy use and cost as well as motor and fan efficiency.

Although in the strict sense, fan efficiency is measured in different terms, one should be interested in obtaining the maximum air flow per unit of power input, provided initial cost does not overshadow operating cost. A previous example was taken from Figure 2 where the fan was to operate at 0.125 inch of static pressure. The motor and fan in that case provided 14.6 cfm of air flow per watt of power input. If a total air flow of 23,400 cfm is required, two fans are needed, each with a capacity of 11,700 cfm. From Table 1, select a single fan to provide 23,400 cfm against 0.125 inch of static pressure. In this case, the motor horsepower requirement is 1.5. The typical motor efficiency for this size motor is about 71 percent. Thus, the fan performance will be:

$$(0.71) \times (23,400 \text{ cfm}) \div (1.5 \text{ hp.} \times 746 \text{ watts/hp}) = 14.8 \text{ cfm/watt}$$

Note that there is very little difference in efficiency of these two selections. Initial cost may be the deciding factor.

Assume that a total air flow of 35,000 cubic feet per minute is required. Select from Table 1 the fan with a 5 horsepower motor size to deliver 37,400 cubic feet per minute. Motor efficiency will be about 76 percent for a single phase motor. The fan system efficiency, however, would be:

$$(.76 \times 37,400) \div (5 \times 746) = 7.6 \text{ cfm/watt}$$

Therefore, the efficiency would be very poor. For 2,000 hours of operation per year, three of the 11,700 cubic feet per minute fans will use 4,808 kilowatts per hour, but the 37,400 cubic feet per minute fan will be 9,842 kilowatts per hour, this will amount to a \$251.70 difference in operating

cost per year in favor of the three smaller fans.

When considering energy use, include fan energy requirements as well as motor efficiency.

Tables 2 and 3 show typical operating characteristics of single phase and three phase motors of fractional and integral horsepower sizes. Many farms will not have three phase power available. Check this out before purchasing equipment which uses a three phase motor.

Fan and motor efficiency are both important/ determining the cost of mechanical ventilation. Remember, however, that no matter how efficient a fan is, it will not be economical unless it is installed properly. In most agricultural building systems, fan placement and air inlet and outlet control will be equally important.

Table 2. Single Phase Electric Motors: Operating Characteristics

Standard Motor Size (HP)	Typical Efficiency Full Load (%)	Typical Power Factor Full Load (%)	Full Load Amperes (FLA)	
			115 volts	230 volts
1/4	63	44	5.8	2.9
1/3	66	46	7.2	3.6
1/2	69	48	9.8	4.9
3/4	71	50	13.8	6.9
1	71	57	16	8.0
1 1/2	71	69	20	10
2	73	74	24	12
3	75	76	34	17
5	76	76	56	28
7 1/2	77	79		40
10	78	83		50

$$P \text{ (watts)} = E \text{ (volts)} \times I \text{ (amperes)} \times Pf \text{ (Power factor)}$$

$$KW \text{ (kilowatts)} = E \times I \times Pf \quad Pf \text{ (Power factor)} = \text{Actual Watts}$$

$$HP \text{ (horsepower)} = \frac{E \times I \times Pf \times \text{eff.}}{746}$$

$$HP \text{ (horsepower)} = KW \text{ (input)} \times 1.34 \times \text{eff. (motor)}$$

Table 3. Three Phase Electric Motors: Operating Characteristics

Standard Motor Size (HP)	Typical Efficiency Full Load (%)	Typical Power Factor Full Load (%)	Full Load Amperes (FLA)		
			208 Volts	230 Volts	460 Volts
1/2	72	65	2.2	2	1
3/4	74	68	3.1	2.8	1.4
1	76	68	4.0	3.6	1.8
1 1/2	77	70	5.7	5.2	2.6
2	79	70	7.5	6.8	3.4
3	80	73	11	9.6	4.8
5	82	75	17	15.2	7.6
7 1/2	83	77	24	22	11
10	84	78.6	31	28	14
15	85	78.6	46	42	21
20	86	80	59	54	27
25	86	80	75	68	34
30	87	80.7	88	80	40
40	88	81.8	114	104	52
50	89	81	143	130	65
60	90	81	169	154	77
75	91	80.3	211	192	96
100	92	82	273	248	124
125	92	82	343	312	156
150	94	83	396	360	180
200	94	83	528	480	240

$$HP \text{ (horsepower)} = \frac{E \times I \times 1.732 \times Pf \times \text{eff.}}{746}$$

$$HP \text{ (horsepower)} = KW \text{ (input)} \times 1.34 \times \text{eff. (motor)}$$

Fan Maintenance

Fans represent a sizeable investment which should provide many years of service. Getting the most from ventilating equipment requires that it be properly maintained. Keep fans clean. Dust holds moisture and will result in rusting and deterioration as well as a reduction in air-moving efficiency. It is most important to keep the fan motors and automatic louvers clean.

Dirty motors overheat, causing the breakdown of motor winding insulation which will shorten motor life. Select the right motor for the conditions. Dirty louvers increase the pressure required to open them, reducing fan capacity.

Periodic repainting of painted fan blades and housings can reduce rusting and prevent premature failure. Check fan shaft bearings on belted fans and replace when worn. Lubricate as indicated by manufacturer.

Cover a fan opening with 1/4-inch or 1/2-inch hardware cloth or another safety cover to prevent injury to workers. Check louvers for ease of operation. Lubricate and straighten louver parts when necessary to prevent binding.

Be sure fan belts are tight and in good condition. Belt slippage can result in 10 percent or more loss in overall air moving efficiency. For A-section V-belts, commonly used for fan drives, the belt deflection at mid-span between pulleys should be about 1/64 inch per inch of span when applying a deflection force of about 5 to 6 pounds as shown in Figure 3.

This recommendation will vary with smaller pulley sizes and speed ratios, but the value given above will be about right for most belted ventilating fans.

Proper installation and wiring is important. Motors should be individually protected against overload with time delay fuses sized to the full

load motor amperage. Check with the fan supplier if there is a question about the full load current requirement. In addition to motor protection, be sure wiring is adequate sized to

carry the amperage of all the fans supplied by a particular circuit. Low voltage will reduce efficiency.

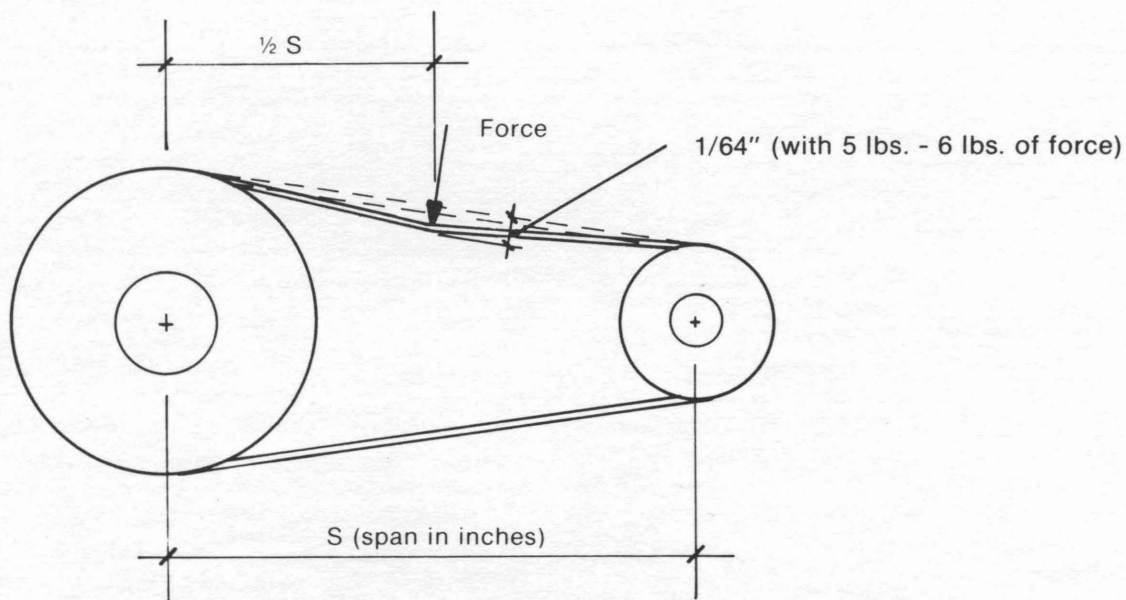


Figure 3. Technique for checking Belt Tension

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