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Agricultural and Biological Engineering

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Selecting Rated Ventilation Fans

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Select an agricultural ventilation fan for the conditions under which it will be operating in your livestock housing or greenhouse setting. The best and easiest way to select fans is by considering only "rated" fans. Fans are rated when they are run through a series of standardized performance tests by a certified laboratory such as the Air Movement and Control Association (AMCA) or the Bioenvironmental and Structural Systems Laboratory (BESS). In order to know the air delivery capabilities of a fan, these performance data must be available. These data are most useful when the fan was tested under conditions that *match* your application.

Fans create the static pressure and flow of a ventilation system. Find a range of fans that are suitable for your situation and then make a selection based on the following criteria:

- Quantity of air delivered at desired static pressures
- Energy efficiency (cfm/watt)
- Quality and durable construction
- Dealer service
- Cost

This fact sheet provides information about the use of rated fan data. A case study is included.

Important factors to consider include the static pressure against which the fan will be operating and the type of accessories installed with the fan. Total ventilation system static pressures normally vary from 0.08 to 0.20 inches of water. For initial estimates, evaluate a fan's performance based on its air flow capacity at 0.10 or 1/8-inch (0.125-inch) static pressure. Once the ventilation system design is more complete, use the best estimate of static pressure the fan will actually operate under. Table 1 shows resistances to air flow that a fan must overcome in an agricultural application. Equipment, ducts, dirt, and wind each provide resistance to air flow and, hence, decrease fan performance.

When comparing fans of different sizes or from different manufacturers, study their rated performance data. This information consists of a table or curve of air flow capacity (cubic feet per minute, cfm) versus static pressure (inches of water). An example of rated fan data is shown in Table 2. A graph of this data, known as a fan curve, is displayed in Figure 1. Both show that as the resistance to air flow increases, as measured by increased static pressure, air flow delivered by a fan decreases.

Table 1. Typical Resistances to air movement.

Total static pressure the fan must overcome is the sum of the individual resistances.

		Static Pressure in. H_20
Properly sized and managed inlet		0.04
Shutter	clean dirty	0.02-0.10 0.05-0.20
Exhausing against wind (no wind shielding)	5 mph 10 mph 15 mph 20 mph	0.02 0.05 0.10 0.20
Fan guards, clean	wire mesh round ring	0.05-0.15 0.01-0.02
Ducts	geothermal tubes solar collector	0.5-1.5 0.2-1.0

Source: MWPS-32 *Mechanical Ventilating Systems for Livestock Housing (2)*

It is important to evaluate and select fans that have been tested under conditions similar to those in your facility. Any increased static pressure caused by operating conditions or accessories needs to be accounted for in ventilation system design. For example, if your fan will have shutters and a guard then evaluate data where the fan was rated with shutters and guard in place. If that information isn't provided, you can add the static pressure resistance associated with these accessories, as shown in Table 1, to your estimate of the total static pressure against which the fan will operate.

Manufacturers offer fan performance data for bare fans with no additional equipment in place. This is not typical of an installed agricultural fan. Most manufacturers also offer fan performance data with various equipment options in place. Ask for this more appropriate data or be sure to account for the resistance to air flow that these accessories cause. Table 3 shows the same fan as in Table 1 but with the addition of a shutter and guard during the rating test. Figure 2 shows this fan's test results both as a bare fan and with guard and shutters in place (using data from Tables 1 and 3). Note that decreased air flow from fan accessories is important. Design air flow will not be met if accessories are ignored. In the case study presented later, a set of stage-one fans were installed with discharge side shutters, yet bare fan data were used in specifying the type and number of fans. The building was under-ventilated when stage-one fans were operating.

Table 2. Rated fan performance data example showing air flow capacity (cfm) versus total static pressure the fan is operating against (inches of water).

Static Pressure	CFM
0	23963
0.04	22979
0.05	22703
0.1	21503
0.13	20666
0.15	20011
0.2	18328
0.25	16215
0.3	13883

Manufacturer X
48-inch fan
1 Hp
Belt drive
510 RPM

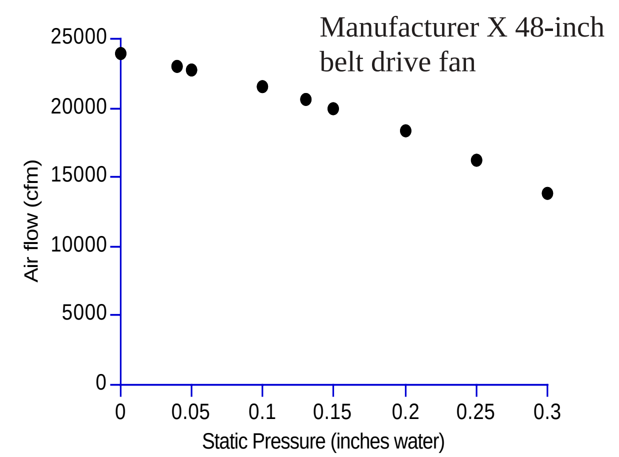

Figure 1. Example fan curve of rated 48-inch fan data from Table 2. All fans exhibit decreased cfm with increased static pressure. Good fans have relatively flat curves indicating dependable air flow capacity across a wide range of operating static pressures.

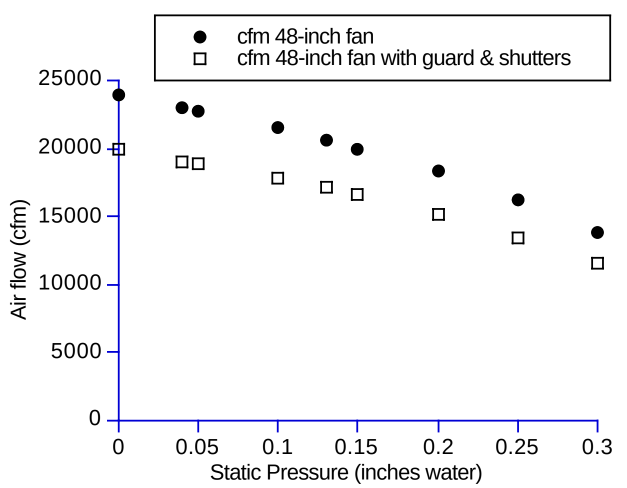

Figure 2. Performance curves for a 48-inch belt drive fan rated as a bare fan and with guard and shutters. Agricultural fans are typically installed with a guard and shutters so the rated data should include these accessories.

Table 3. Example manufacturer data showing a fan tested with typical agricultural accesssories in place.

Static Pressure (inches water)	CFM
0	19889
0.04	19073
0.05	18843
0.1	17847
0.13	17153
0.15	16609
0.2	15212
0.25	13458
0.3	11523

Manufacturer X
48-inch fan
1 Hp
Belt drive
510 RPM
Shutter & Guard

What Kind of Accessories Will an Agricultural Fan Need?

Accessories are necessary for proper functioning of the fan as part of a ventilation system, even though they reduce air flow and efficiency. Typical equipment installed on a fan includes a guard, which prevents things from contacting the blades, and shutters, which seal the fan opening when that fan is not in use. Guards always should be installed for safety reasons. Shutters are used on either the inside or outside of most fans.

Shutters reduce air flow and efficiencies of a fan by 10 to 25 percent. This is a very significant loss. Shutters placed on the discharge side of fans are particularly detrimental to air flow. Air exiting the fan blades circulates strongly in a spiral pattern, but this fast-moving, circulating air is disrupted by horizontal shutters. Shutters on the inlet side of fans are less detrimental to performance. Inlet air flow is less defined into any pattern that the shutters could disrupt. Expect a 10 to 15 percent air flow reduction using inlet-side shutters and a 15 to 25 percent reduction using discharge-side shutters. For stage-one fans which operate continuously, year-round, shutters can be removed for improved air flow. Additional fans, staged to operate in warm or hot weather, need shutters to seal the fan opening when the fan is not in use. Without shutters, a fan opening will act as an inlet and hence disrupt the ventilation system air flow and static pressure.

Guards are necessary for the safety of people and animals around the fan. They also prevent objects from damaging the fan. Guards will disrupt air flow and efficiency by less than 5 percent. Round ring guards with concentric circles of wire disrupt air flow less than wire mesh guards. Install a guard on any side not protected with fan shutters.

Fan performance will be improved with a well-designed housing and inlet or discharge cones. Streamlined air flow improves fan capacity and is particularly effective with inlet cones. Discharge cones offer some air flow improvement and will provide the fan some protection from weather. A well-designed fan has a tight clearance between fan blade tips and its housing. This discourages air from coming off the blade tips and flowing backwards through the housing.

Comparing Fan Performance

Fan performance can vary widely among manufacturers and models. Figure 3 shows average, worst, and best cases of air flow performance for thirty-five 36-inch fans tested at the BESS laboratory. At 0.10 static pressure, a 36-inch fan may deliver as little as 6200 cfm for the worst performer up to 13,000 cfm for the best fan. By selecting the fan that performs best, one can double the air flow capacity of a ventilation system. These data underscore the necessity to check rated fan data rather than relying on a "rule of thumb" which states that a 36-inch fan provides 10,000 cfm. A rule of thumb is acceptable for a first estimate, but specific rated fan data should be used in final ventilation design specifications.

Select energy-efficient fans which have a high cfm per watt ratio at the static pressure of your system. Efficient fans have high output in cfm with lower input cost in kilowatt hours (kwh) of electricity. Again, the fan efficiency should represent conditions in which the fan will be operated. Figure 4 shows the variation in energy efficiency found among the thirty-five 36-inch fans tested at BESS.

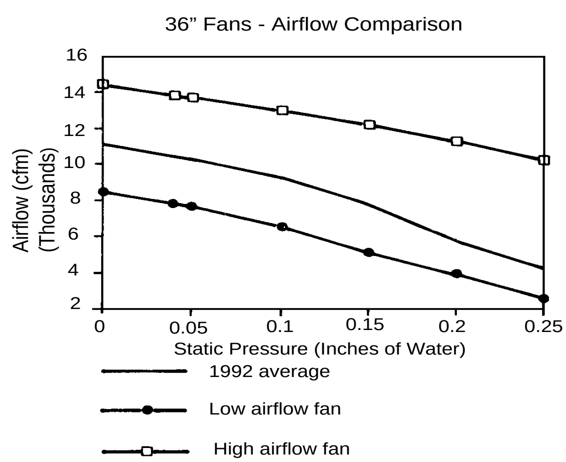

Figure 3. Variation in airflow for 36-inch fans based on dozens of fan tests at BESS. Average air flow capacity of a 36-inch fan is around 10,000 cfm, but depending on its design, it may deliver as little as 6200 cfm for the worst performer up to 13,000 cfm for the best fan (evaluated at 0.10 inches of water). The best fans also have desirable, relatively flat performance curves across the range of operating static pressures from 0.08 to 2.0 inches water.

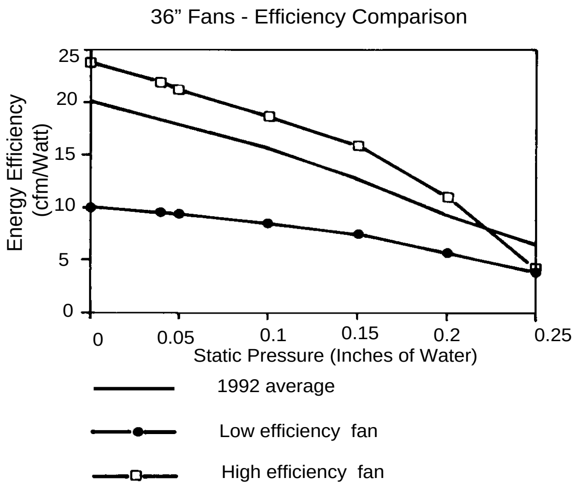

Figure 4. Variation in efficiencies of 36-inch fans in cfm/watt. The best fans are almost twice as energy efficient as the worst fans.

Case Study

During spring 1995, a caged layer poultry house ventilation system was evaluated. This facility housed 120,000 caged laying hens in a turbo ventilated 40 foot by 420 foot building. Fans were positioned under light trap hoods. The house had ten 36-inch and twenty-four 48-inch fans. Preliminary measurements indicated that the ten 36-inch, continuously running, stage-one fans were not delivering their expected cfm capacity under spring conditions. Also in question was whether they could maintain adequate performance during warm weather, when they would operate against higher static pressures.

Fans at the site were evaluated using a vane anemometer to measure air velocity (Figure 5) and an inclined manometer to measure static pressure difference (Figure 6) See resources on back page for more instrument information. Blade rpm was measured with a tachometer and found to be correct. Although air flow capacity of the 36-inch fans was in question, one 48-inch fan was evaluated to determine how the whole ventilation system was performing. One 36-inch fan was evaluated at several static pressure levels to determine a characteristic fan curve. The poultry house was operating under normal spring conditions of 0.05-inch static pressure with four of the seven stages of fans operating (all ten 36-inch fans and twelve of the twenty-four 48-inch fans).

A vane anemometer was positioned at nine locations across the discharge side of each fan face to find an average air velocity (Figure 7). Fan velocities varied widely around the face of the fan, as would be expected with the obstruction of a light trap hood. This technique of taking many air velocity readings across the discharge side of a fan face is a crude field technique for determining an average velocity for air volume measurements. When properly executed, it should provide a good estimate, however, the technique may over- or under-estimate fan performance by as much as 20 percent. The more measurements taken, the better the estimate. (See resource 3 for more details on how to take measurements.)

Based on the average air velocity measurements, fan capacity in cfm was calculated (ft/min velocity * ft^2 area = cfm). Each 36-inch fan provided about 7580 cfm, while the 48-inch fan provided 17,640 cfm. These capacities were compared to the fan manufacturer's characteristic curves (shown in Tables 4 and 5) used to design this ventilation system. The 48-inch fan’s rated capacity at 0.05-inch static pressure is 19,200 cfm, which is 8 percent more than our measured air flow. The 36-inch fan has a rated output of 10,310 cfm at 0.05-inch which is 26 percent greater than our measured air flow. Design ventilation rates for this layer house were 5 cfm per bird under summer conditions. With the large decrease in air flow from the 36-inch fans, the house would be under-ventilated.

The 48-inch fan performance decrease of 8 percent is tolerable since rated fan tests can tolerate a 6 percent variation between fans (1). In addition, the air velocity field measuring technique provides rather crude values. The 36-inch fans were operating with mechanized shutters on the outside and a guard on the inside. External shutters, especially, will greatly decrease air flow. The manufacturer’s rated data does not mention shutters, so there probably were none installed on the test fan. It would be more appropriate to compare the poultry house fans with data from a similarly operated test fan, i.e. one with guard and external shutters. These accessories are probably enough to account for most of the 26 percent difference between the measured air flow values and the manufacturer air flow values of a bare fan. Discharge-side shutters can reduce air flow and efficiencies of fans by up to 25 percent. Guards can reduce air flow up to 5 percent (1).

Case Study Recommendations

Analysis indicated that the 36-inch fans in the poultry house were performing well below their rated cfm capacity at typical static pressure levels. It turned out that their “rated” capacity was based on fan performance data of a bare fan, whereas the installed fans had a guard on the inside and shutters on the outside. These two pieces of equipment were enough to potentially decrease the fan performance up to 30 percent.

There are several ways to improve the performance of the 36-inch fans. One is to move the shutters from the discharge to the intake side for a 10-15 percent air flow improvement. A better option is to remove the shutters entirely for a 15 to 20 percent air flow increase. The 36-inch fans are stage-one, continuously operating fans with continuously open shutters. Fan shutters are only useful when the fan is off. A guard will be necessary when the shutters are moved or removed.

Future ventilation system designs should use rated fan data that account for the accessories the fan will use when installed.

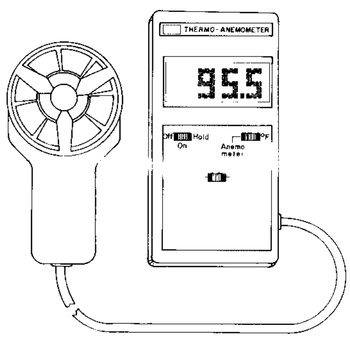

Figure 5. Vane Anemometer

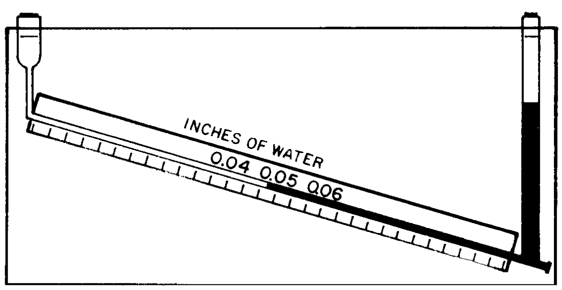

Figure 6. Inclined manometer

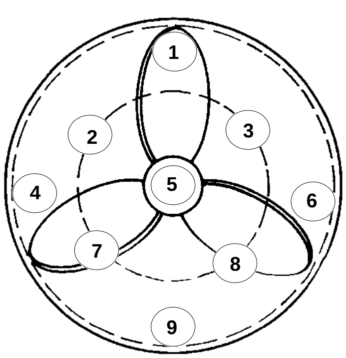

Figure 7. Air velocity readings were taken at nine locations across the fan face to determine an average velocity for air flow capacity calculation.

Summary

Ventilation system designs should use data from fans tested in the condition and with the accessories, such as guards and shutters, under which they will be operated. The specification for this case study ventilation system used two manufacturers’ fans. The 48-inch fans were chosen based on performance data which included fan accessories. By contrast, the 36-inch fans were evaluated in unrealistic conditions, without shutters and a guard. This resulted in inadequate air exchange conditions in the poultry house.

As important as fan selection is, remember that good ventilation depends on a complete system, and the fan is just one component. Proper selection and operation of fans will ensure adequate air exchange, while inlet design is tremendously important for proper air distribution.

Table 4. 36-inch fan used in poultry house case study. Rated data used in design was a bare fan whereas installation included guard and external shutters.

Static Pressure	CFM
0	11200
0.05	10310
0.10	9440
0.14	8780

Manufacturer A
36-inch fan
1/2 Hp
Direct drive
840 RPM

Table 5. 48-inch fan used in poultry house case study. Rated data appropriately includes guard and shutter on fan.

Static Pressure	CFM
0	20000
0.05	19200
0.10	18200
0.125	17500

Manufacturer B
48-inch fan
1 Hp
Belt drive
417 RPM
Shutter and guard.

Additional Resources:

(1) *Agricultural Ventilation Fans Performance and Efficiencies.* 1993. Ford, Christianson, Riskowski, Funk. BESS Laboratory, Department of Agricultural Engineering, University of Illinois.

(2) *Mechanical Ventilating Systems for Livestock Housing.* MWPS-32. 1990. MidWest Plan Service, Iowa State University.

(3) Evaluating Livestock Housing Environments. 1995. E. F. Wheeler and R. Bottcher. Three-part fact sheet series. *Principles of Measuring Air Quality*-G80, *Instruments for Measuring Air Quality*-G81, and *Evaluating Mechanical Ventilation Systems*-G82. Agricultural and Biological Engineering Department, Pennsylvania State University.

(4) *Choosing Fans for Livestock and Poultry Ventilation*. 1995. J. D. Harmon and H. Xin. Department of Agricultural and Biosystems Engineering, Iowa State University.

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