

Guidelines for Selection of Energy Efficient Agricultural Ventilation Fans

Developed by the Energy and Utilization Committee; approved by the Information and Electrical Technologies Division Standards Committee; adopted by ASAE February 1997; reaffirmed for five years December 2001.

1 Purpose and scope

Ventilation in many agricultural livestock and crop buildings and structures is crucial to maintain animal health or crop quality. Agricultural operations may have large numbers of ventilation fans operating for extended time periods making ventilation a large electrical consumption end use. Unlike other electrical energy-consuming equipment, there is little opportunity to manage operational schedules and electrical use of ventilation fans on a daily or seasonal basis without severely affecting operational management and having adverse affects. Improving the energy efficiency of an agricultural fan is the only practical way to reduce electrical energy use for ventilation. Energy efficient ventilation fans use less electrical power to move equivalent amounts of air, resulting in energy savings. This Engineering Practice is intended to provide information helpful in making decisions involving selection of energy efficient ventilation fans in agricultural operations.

2 Normative references

ANSI/AMCA 210-85, *Laboratory Methods of Testing Fans for Rating*
ANSI/ASAE S493 JUL93, *Guarding for Agricultural Equipment*
ANSI/ASHRAE 51-1985, *Laboratory Methods of Testing Fans for Rating*
ANSI/NFPA 70, *National Electrical Code*
ASAE EP 270.5 DEC94, *Design of Ventilation Systems for Poultry and Livestock Shelters*
IEEE 112-Method B, *Standard Test Procedure for Polyphase Induction Motors and Generators*
NEMA MG 1.1, *Tests and Performance of AC Fractional and Integral Horsepower Motors*
OSHA 29CFR 1910.147, *Control of Hazardous Energy Sources (Lockout/Tagout)*

3 Definitions

3.1 air flow rate: The volume of air moved by the ventilation fan, L/2 (ft³/min).

3.2 fan efficiency: The volumetric airflow rate per unit of input power. Sometimes referred to as the *ventilating efficiency ratio* (VER), Ls⁻¹W⁻¹ (ft³/min/W).

3.3 static pressure: The portion of air pressure due to compression of the air. This is the difference in air pressure between the inside and outside of a building due to airflow resistance created by restrictions such as inlet vents, cooling pads, exhaust outlets, fan shields and louvers, prevailing breezes, etc., Pa (in. H₂O).

4 Agricultural ventilation fan components

The typical parts of agricultural ventilation fans and their effects on fan efficiency include the following:

4.1 Fan motors. Fan motors range in size from fractional horsepower to large horsepower electric motors. Common motor types used for agricultural ventilation fans are split phase, permanent split capacitor, capacitor start, capacitor start-capacitor run, and three phase motors. Split phase and capacitor start motors are medium energy efficiency motors commonly used on direct and belt drive fans. Capacitor start-

capacitor run motors are often used on direct and belt drive fans and are high efficiency motors. Some motor types do not lend themselves to variable speed control using variable voltage controllers. The speed of permanent split capacitor motors can be controlled using a variable voltage controller provided the permanent split capacitor motor was designed for this type of service. Information on electric motor efficiency ratings and test methods can be found in IEEE Standard 112-B or NEMA Standard MG-1.

4.2 Fan blades. Most agricultural ventilation fans are propeller type fans. Propeller fans are ideal for moving large amounts of air at low static pressures seen in agricultural applications. Conditions inside agricultural buildings may be corrosive, requiring heavy gauge fan blades made from corrosion resistant materials. The blades may be constructed of many different materials including stamped steel, stamped aluminum, cast aluminum, molded fiberglass, and plastics.

4.2.1 Direct drive fans. The fan blade is mounted directly on the motor shaft and driven directly by the motor. This arrangement results in minimal losses in efficiency between the motor and fan blades themselves. Common sizes of direct drive agricultural ventilation fans include 20, 25, 30, 35, 40, 45, 50, 55, and 60 cm (8, 10, 12, 14, 16, 18, 20, 22, and 24 in.) fans.

4.2.2 Belt-driven fans. For noise and vibration control and to utilize commonly available 1725 r/min motors, most 90 cm (36 in.) and larger fans are belt driven. This allows the use of high efficiency 1725 rpm motors to run the fan at slower operating speeds ranging from 400 to 800 r/min. A drawback to belt drives is the maintenance requirement, since large efficiency losses can occur if belts are not aligned or tensioned correctly. Some manufacturers provide spring loaded belt tensioners to keep belt tension constant over longer periods.

4.3 Fan housing. The fan housing supports the motor and fan shaft bearings and may be designed so that attachments such as shutters and guards can easily be installed. Depending on the application, the housing may be constructed of galvanized steel, fiberglass, plastic, wood, or other corrosion resistant materials. Factors such as the amount of intake area in the fan housing and length and shape of the housing affect the overall efficiency of the ventilation fan unit as a whole. Well-designed fan housings reduce air restriction and air turbulence and increase fan efficiency.

4.4 Shutters. Shutters may be located on the inlet or discharge side of the fan. Shutters exclude rain and cold air while the fan is not running and are needed for fans that do not operate continuously. A typical shutter may reduce airflow and efficiency from 2% to 25% compared to the same fan without a shutter. Shutters should be corrosion resistant and easy to clean and should close completely when the fan stops. Shutters are of two general types; motor-activated and air-activated. Motor-activated shutters lift and close automatically. They work well even when dirty or when the joints get stiff, providing positive closure to prevent heat loss from the building.

4.5 Guards. Guards are essential for safety of people and animals around the fan. Most fans come equipped with some type of safety guard to prevent body parts and other items from entering the space where the fan blades rotate as well as to protect the fan from being damaged by large objects that might strike the blades. Guards typically reduce airflow and efficiency by less than 5%. Guards should be closed enough to prevent hands and other body parts from entering, as well as birds, but should not restrict airflow. ANSI/ASAE S493 provides general guarding guidelines to minimize the potential for personal injury.

4.6 Other Accessories

4.6.1 Discharge cones. These cones attach to the exhaust side of the fan and expand gradually to reduce turbulence so less energy is required to move a given volume of air. Discharge cones can increase fan airflow and the resulting fan efficiency up to 15%.

4.6.2 Wind hoods and deflectors. These attachments are designed to lessen the effects of wind blowing into the fan and are often installed on ventilation fans that operate continuously during windy months. These hoods lower efficiency slightly during times without wind but provide more even airflow rates during windy, gusty weather.

5 Performance test data

The sole purpose of a ventilation fan is to move air, so it is important to know how much air flow any given fan will deliver against a given static pressure. Many manufacturers test fans and report fan performance data. It is important to know at what static pressure(s) the test was performed and what equipment was installed on the fan during the tests. Tests should be performed over a range of normal operating static pressures with the appropriate standard equipment such as shutters, guards, discharge cones, wind hoods, etc. normally found on the particular model of fan.

5.1 Common static pressures for agricultural ventilation fans. Agricultural fans usually operate against static pressures of between 0 and 60 Pa (0.25 in. H₂O) in a building. A fan attached to a tube, duct, or evaporate pad may operate against static pressures as high as 60 to 120 Pa (0.25 to 0.5 in. H₂O). It is important to know the airflow rate at these varying static pressures since a fan delivers less airflow when it works against a higher static pressure. Normally fan airflow rate at 25 or 30 Pa (0.10 or 0.125 in. H₂O) static pressure is about 80% of the free air capacity when no resistance is offered to the fan. If a fan's free air delivery rating is 5000 L/s (10,000 ft³/min) it will most likely only deliver approximately 4000 L/s (8,000 ft³/min) when operated against the normal static pressure of a building. Table 1 indicates approximate operating static pressures for ventilation under varying conditions.

5.2 Manufacturer's energy ratings for agricultural ventilation fans. A complete manufacturer's fan test should include data from fan testing with:

- A standard production motor;
- A standard production fan housing;
- A standard production fan blade;
- A shutter or alternative backdraft damper (exception: manure storage pit fans which run continuously do not need to be tested with shutters or dampers);
- A protective screen or guard on the unprotected side of the fan blade;
- A complete drive system as called for by the fan application (belt driven fans should be tested with fixed pitch sheaves).

A complete fan test may also include wind hoods or deflectors and/or a discharge cone if appropriate. If published fan efficiency data are not available for a fan, contact the manufacturer and ask for the fan efficiency ratings. Ask whether independently tested fan performance data are available, and request a description of the fan test method,

Table 1 – Typical operating static pressures for agricultural ventilation fans

	Pa	H ₂ O
Circulation fan, free air	0.0	0.00
Exhaust fan, no wind or obstacles	10.0–25.0	0.05–0.125
Exhaust fan through evaporative pad system	20.0–100.0	0.10–0.50
Exhaust fan, manure pit duct	40.0–100.0	0.20–0.50
Exhaust fan, pressure drop due to wind	20.0–100.0	0.10–0.50
Pressure drop through earth tubes	10.0–30.0	0.05–0.15

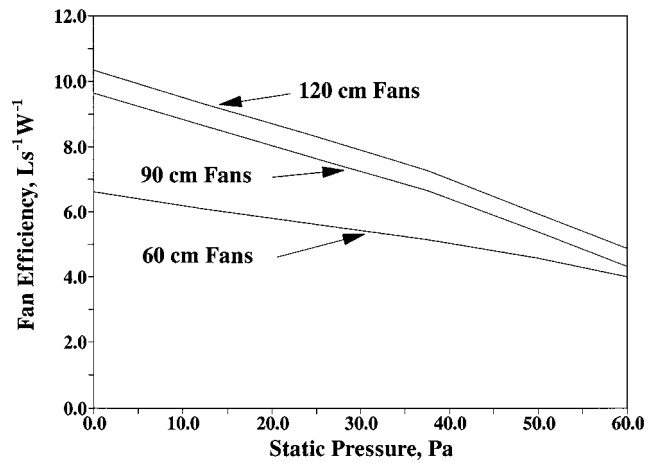


Figure 1 – Graph of fan efficiency versus static pressure (SI units)

including the equipment on the fan during the test, and the static pressures the fan was operated against. Consistently tested and reported agricultural fan efficiency ratings may not be readily available. Some manufacturers publish energy efficiency data for their agricultural fans; however, others have not made these figures readily available. Companies who publish data may not have tested fans in the same manner as other companies so direct comparisons of fan efficiencies may not be accurate.

5.3 Necessary manufacturer's test data for evaluation of energy efficient fans. The most reliable agricultural fan performance data consist of test data measured by standard testing procedures outlined by ANSI/ASHRAE 51-1985 (also listed as ANSI/AMCA 210-85) and acquired with all blades, shutters, guards, and other accessories in place on an actual "as sold condition fan." The following information reported at typical static pressures of 0, 10, 20, 30, 40, 50, 60, and possibly 120 Pa (0.00, 0.05, 0.10, 0.15, 0.20, 0.25, and possibly 0.50 in. H₂O) should be available from these types of tests.

- Airflow produced, L/s (ft³/min);
- Fan rotational speed, r/min;
- Input power, W or hp;
- Fan efficiency, Ls⁻¹W⁻¹ (ft³/min/W);
- Power factor rating, (%).

6 Energy efficient ventilation fan selection criteria

Agricultural ventilation fans should be selected to adequately accomplish the ventilation task in the intended environment and to operate in an

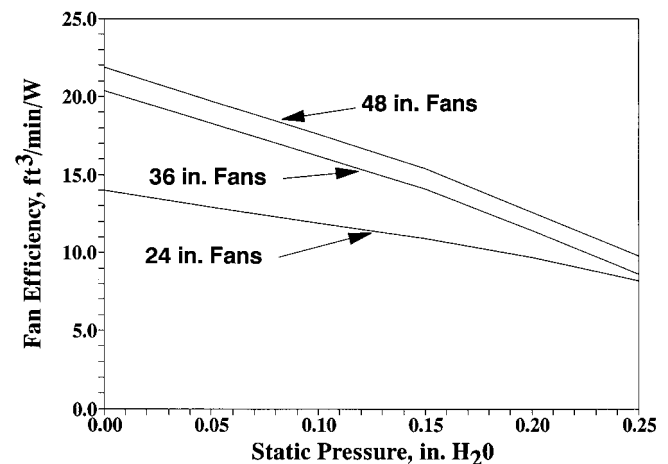


Figure 2 – Graph of fan efficiency versus static pressure (English units)

efficient manner. General ventilation requirements in agriculture are based on air flow rates necessary to control temperature, moisture, or gases. Refer to ASAE EP270. Efficiencies of agricultural ventilation fans can vary greatly for similar size fans operating against equivalent static pressures. Selecting a higher efficiency ventilation fan will reduce the electrical operating costs of the fan. In many cases, electrical operating costs will far exceed the purchase price of the fan, so electrical energy savings may exceed any extra purchase cost of an energy efficient fan over its useful lifetime.

6.1 Consider total costs instead of initial purchase cost. When selecting ventilation fans, try to obtain the maximum air flow per unit of power input, $Ls^{-1}W^{-1}$ ($ft^3/min/W$), providing initial cost does not overshadow any overall savings in operating costs. Table 2 presents the minimum recommended efficiencies for energy efficient agricultural ventilation fans. It is desirable to select a fan exceeding these minimum efficiencies at the desired static pressure operating point for a particular size of fan.

6.2 Calculating operating cost savings from energy efficient ventilation fans. When two or more fans are available to accomplish the same ventilation job, consider the economics of each alternative. Total ventilation fan costs include initial cost, interest on investment, and maintenance and operating costs. Operating costs are affected by energy use and cost as well as the overall fan efficiency. The following equation can be used to calculate the annual electrical operating cost savings (EOCS) when comparing two different ventilation fans:

$$\left(\frac{AFR_1}{FE_1} - \frac{AFR_2}{FE_2} \right) \times AOH \times ER \times 0.001 = EOCS$$

where:

AFR_1 is air flow rate, L/s (ft^3/min), of fan No. 1 at the selected static pressure;

FE_1 is fan efficiency, L/s/W ($ft^3/min/W$), of fan No. 1, the fan with the lower fan efficiency at the selected static pressure;

AFR_2 is air flow rate, L/s (ft^3/min), of fan No. 2 at the selected static pressure;

FE_2 is fan efficiency, L/s/W ($ft^3/min/W$), of fan No. 2, the fan with the higher fan efficiency at the selected static pressure;

AOH is average operating hours per year, h/yr, for the fan;

ER is electric rate (dollars/kWh) charged by the electric power supplier;

$EOCS$ is electric operating cost savings per year, dollars/yr, in energy costs between the two fans.

6.3 Compare energy savings per year to useful life of fan. The result of the previous calculation will indicate the difference in electric operating costs per year between the two fans and give an indication of how much savings in energy cost can be used to offset any increase in purchase cost of the more energy efficient fan. In order to break even economically, any increased purchase cost of an energy efficient fan

Table 3 – Recommended minimum efficiencies for energy efficient agricultural ventilation fans (24, 36, and 48 in. sizes)

Static pressure (in. H ₂ O)	Fan efficiency, ft ³ /min/W		
	24 in. fans	36 in. fans	48 in. fans
0.00	14.0	20.4	21.9
0.05	12.9	18.3	19.7
0.10	11.9	16.2	17.6
0.15	10.9	14.1	15.4
0.20	9.7	11.4	12.6
0.25	8.2	8.6	9.8

should be recouped by cost savings over the useful life of the fan. The following equation can be used to compare the total savings of selecting the energy efficient fan over the rated life of the fan:

$$\left(\frac{RL}{AOH} \times EOCS \right) - (PP_1 - PP_2) = EEFS$$

where:

RL is rated life of fan in hours, h;

AOH is average operating hours per year, h/yr, for the fan;

$EOCS$ is electrical operating cost savings per year, dollars/yr, in energy costs between the two fans;

PP_1 is purchase price of fan No. 1, the energy efficient fan, dollars;

PP_2 is purchase price of fan No. 2, the standard efficient fan, dollars;

$EEFS$ is energy efficient fan savings, dollars, total savings of selecting the higher efficiency fan.

6.4 When fan efficiency test data are not available. If test data or information for air flow rate and fan efficiency for the fans under consideration are not available, the following generalizations may be helpful in choosing the most energy efficient fan.

6.4.1 A larger diameter fan is generally more efficient than a smaller one. The larger diameter blades will generally move more air per unit of input power.

6.4.2 For any given area, a few larger fans are usually more efficient than many smaller fans.

6.4.3 For any two fans with the same air flow rate, diameter, voltage and motor horsepower, the fan with the smaller full load ampere (FLA) rating is generally the more energy efficient fan.

6.4.4 Dual capacitor (capacitor start-capacitor run) motors are the most energy efficient single phase electric motors and the most expensive. They are generally not available below 375 W (0.5 hp). Other types of single phase motors are less efficient. (Refer to NEMA MG-1.)

Table 2 – Recommended minimum efficiencies for energy efficient agricultural ventilation fans (30, 60, and 90 cm sizes)

Static pressure, Pa	Fan efficiency, Ls ⁻¹ W ⁻¹		
	60 cm fans	90 cm fans	120 cm fans
0.0	6.6	9.6	10.3
10.0	6.2	8.8	9.5
20.0	5.8	8.0	8.7
30.0	5.4	7.2	7.9
40.0	5.0	6.4	7.0
50.0	4.6	5.4	5.9
60.0	4.0	4.3	4.9

7 Ventilation fan maintenance

Keeping a fan in good repair is as important in reducing energy costs as buying the most efficient model. Poor maintenance can reduce a fan's efficiency by 50% or more. Ventilation fans should be checked at least every one to three months. For applications where excess dust builds up on the fan blades, housing, or motor, more frequent servicing may be required.

7.1 Maintenance and service considerations

7.1.1 Before servicing the fan, unplug the cord or turn off the switch to disconnect power to the fan. Never do maintenance or repair work on a ventilation fan without the fan motor de-energized. Refer to OSHA 29 CFR 1910.147.

7.1.2 Clean any accumulated dust and debris from the blades, housing, guards, and motor because clean surfaces allow the fan to push more air with less power.

7.1.3 Check the tension on the belt drive if equipped. Belt adjustment is the single biggest maintenance problem with some fans. Belt-driven fans must be regularly adjusted to maintain full air movement, so they should be located where they are easy to adjust. Belt slippage reduces air flow, reduces efficiency, and increases belt wear. An excessively tight belt can cause excessive belt wear. When a new fan or a new belt has been installed, the belt should be re-adjusted after two weeks of operation to take up the initial stretch.

7.1.4 Turn the blades slowly to assess the condition of any bearings in the motor or the drive system. Check for looseness or noise indicating a worn bearing that needs to be replaced. Sealed bearings should be used in most agricultural ventilation fan applications to lessen maintenance requirements and eliminate the requirement for a specific maintenance schedule.

7.1.5 If equipped, fan shutters should be checked for free operation. Shutters should close tightly when a fan is not operating so outside air is not allowed to infiltrate the building, wasting energy. When the fan is on, the shutters should be fully open and not restrict the flow of air. A restricted fan operates against a heavier load to achieve the desired amount of air movement, which costs more in electricity usage. Shutters that are sticking open or closed can be repaired by cleaning and applying a solvent or lubricant to the hinges. Use graphite or silicon lubricant on shutters rather than oil which attracts dirt and may gum up the joints.

7.2 Safety guards. Fans within reach of personnel and animals shall have safety guards in place to prevent accidents. The guard supplied by the manufacturer will be best because it lowers fan efficiency very little. If you choose to fabricate a guard and it is installed within 10 cm (4 in.) of the moving parts, use a woven wire mesh of at least No. 16-gage with 1 cm (0.5 in.) openings. If the guard can be farther than 10 cm (4 in.) from these parts, use a 5 cm (2 in.), No. 12-gage wire mesh screen that has less air resistance and collects less dust. The guard should be hinged or easily removable for proper fan maintenance. ANSI/ASAE S493 provides general guarding guidelines to minimize the potential for personal injury.

7.3 Fan motor replacement. When replacing motors on existing ventilation fans, match the horsepower, phase, voltage, speed, and frame type of the new motor with the existing motor. The motor efficiency should be the same or higher for the new motor as compared to the old

motor. This information is given on the motor nameplate or the manufacturer's information. If motor efficiency is not provided, compare the full load amperes (FLA) of the new and old motors. The FLA of the new motor should be the same or less than the FLA of the old motor. A totally enclosed farm duty motor should be used with any fan in an agricultural application.

8 Miscellaneous equipment

A number of controls and protective devices can be used in conjunction with an energy efficient fan to improve convenience, operational control, and safety of an agricultural ventilation system.

8.1 Electrical disconnect. Every fan should have its own electrical disconnect. Under no circumstances should the breaker or fuse controlling the circuit on which the fan is connected be used as the sole disconnecting means for the fan. Certain fans with motors 2 hp or smaller may be disconnected using a cord and plug. Fans with larger motors shall have a disconnect switch within sight of and within 15 m (50 ft) the fan motor. Refer to ANSI/NFPA 70, National Electrical Code, for specific rules.

8.2 Overload Protection. Every fan should have its own electrical overload protection. If the manufacturer does not provide this on the fan motor, a time delay fuse or other protection device can be located in the circuit or outlet to which the fan is connected. Refer to ANSI/NFPA 70, National Electrical Code.

8.3 Thermostats. Thermostats are the most common and dependable way to control ventilation fans based on temperature in the facility. The thermostat should be located at a height that approximates the temperature felt by the animals in the building and out of drafts. The calibration of the thermostat should be checked every three months.

8.4 Humidistats. Humidistats are used in many agricultural buildings to control ventilation fan operation based on the relative humidity in the building. Humidistats require frequent maintenance and calibration for accurate performance.

8.5 Timers. Timers are used in many agricultural buildings to control ventilation fan operation and should be occasionally calibrated for accurate performance.