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David P. Shelton
University of Nebraska - Lincoln, dshelton2@unl.edu

Gerald R. Bodman
University of Nebraska - Lincoln

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Ventilation Fans: Efficiency and Maintenance

This publication describes efficiency and design factors to consider when selecting a ventilation fan. Basic maintenance procedures needed for efficient operation are also discussed.

David P. Shelton, Extension Agricultural Engineer
Gerald R. Bodman, Extension Agricultural Engineer-Livestock Systems

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An energy efficient ventilation system requires good design and good equipment. Selecting efficient ventilation fans and keeping them in good working condition will keep operating costs down.

Efficiency Factors

Fan efficiency is often measured by the amount of air moved per unit of electrical energy input to the fan motor. At least five design factors influence the energy efficiency of a ventilation fan. These factors should be considered when comparing and purchasing fans.

Motor efficiency can have a major influence on overall fan and ventilation system energy efficiency, and hence operating costs. Some manufacturers offer fan models with high efficiency motors. Although usually more expensive initially, high efficiency motors can require over 20 percent less energy to operate than low efficiency motors.

Speed of the fan motor and blade also influences fan efficiency. As the speed of a fan increases, turbulence of the air moving through the fan increases and efficiency decreases.

Turbulence is a primary factor influencing the noise level of a fan. A fan or ventilation system does not need to be noisy. High noise levels are an indication of poor design and/or poor equipment selection. For reasonable noise levels and greater efficiency, fan blade tip speed should be less than 4,500 feet per minute (fpm)*. For fan diameters of 12, 24, and 36 inches, this means that the fan blade rotational speeds should be less than 1,440, 720, and 480 rpm, respectively.

Blade design or shape is important for determining the energy efficiency of a fan. In addition, some fan companies utilize blade designs that reduce or minimize the buildup of dirt. This is particularly important because of the high levels of moisture and dust in most livestock housing facilities. Generally, a machete or teardrop shaped blade is more efficient than one shaped like a cloverleaf (*Figure 1*).

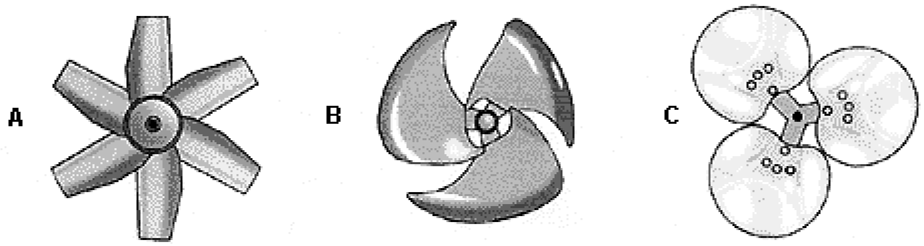

Figure 1. Machete (A) and teardrop (B) shaped fan blades are generally more efficient than cloverleaf (C) shaped blades.

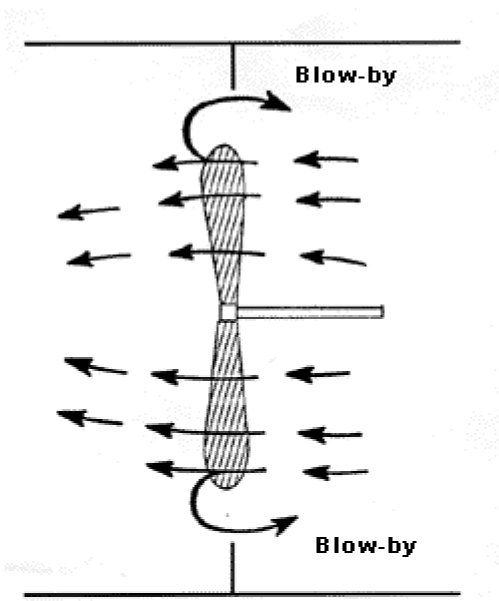

Figure 2. Air "blow-by" caused by excessive clearance between fan blade and housing.

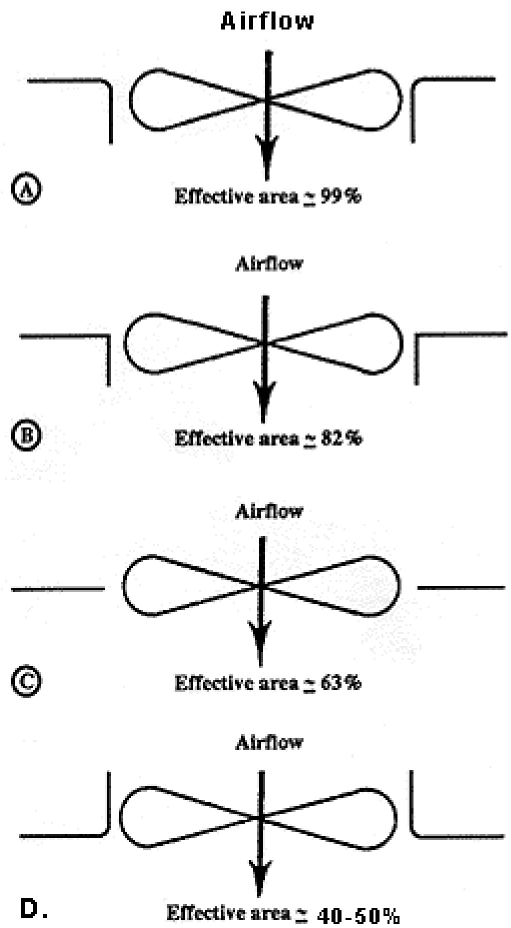

Figure 3. Effect of fan housing design on *vena contracta* and fan air moving capabilities. (These illustrations represent a "slice through the center of the fan." Consider all of the fans to have identical motors and blades, and to be running at equal speed; only the housing shapes are different.)

The ***blade-to-housing clearance*** is important for determining the static pressure capabilities and efficiency of a fan. Fans with large clearances between the tip of the blades and the housing generally have low static pressure capabilities and low efficiencies due to the "blow-by" that occurs during operation of the fan (*Figure 2*). (This blow-by is analogous to the loss of power an engine suffers when the piston rings become worn.)

Housing design also influences fan efficiency. As air enters and moves through an opening, turbulence is created and the effective cross-sectional area of the opening is reduced, a phenomenon known as *vena contracta*. Reducing the effective area of the opening reduces the amount of air that can move through it. The shape of the opening, particularly the point at which the air enters, determines the degree of reduction that occurs. This is illustrated in *Figure 3* for four different fan housing designs.

Note that as the change is made from a smooth-contoured or airfoil shaped surface where the air enters the fan housing (*A*), to one with square corners (*B*), approximately 20 percent reduction in air-moving capabilities occurs. Eliminating the shroud around the fan blade (*C*), can reduce air-moving capabilities another 20 percent. Mounting the fan backwards in the housing, which is sometimes done for ease of mounting the fan against a wall surface (*D*), can result in a 50 to 60 percent reduction in fan performance.

Efficiency Ratios

The five factors previously mentioned, as well as others, combine to determine overall ventilation fan and system efficiency. One measure of fan efficiency is the cubic feet of air moved per minute (cfm) for each watt (W) of electrical power input. The cfm/W ratio is also called the Ventilating Efficiency Ratio (VER). VER ratings for fans range from about 5 to 25, with most being in the 10-15 range. (The larger the VER rating, the greater the efficiency.)

To illustrate the effects of fan efficiency, consider two 36-inch diameter fans with 1/2 hp motors and performance rated at 9,500 cfm when operating at a static pressure of 0.125 in. H_2O. One fan has a VER of 20, the other a VER of 10. The more efficient fan is priced $150 more. If the fan will operate 40 percent of the time during a given year and the cost of electricity is 7 cents per kilowatt hour (kWh), which is the better buy?

Calculations for the more efficient fan (VER = 20) yield an estimated annual energy use of 1,665 kWh. At 7 cents per kWh, the cost of electricity to operate this fan is $117 per year. The annual electricity cost to operate the other fan, which is only half as efficient (VER = 10), is $234. Thus, the more efficient fan saves $117 in electric bills each year, a 78 percent return on the extra investment of $150. If the fan lasts for 10 years, the savings are nearly $1,200, without accounting for any electric rate increase. Also, more efficient fans may be of better quality construction and thus may last longer than less efficient ones. Therefore, the life cycle savings may be even greater.

At present, only a few manufacturers have published energy efficiency data for their fans, while some others will supply this information on request. If VER data are not available a modified efficiency ratio can be determined by dividing the cfm rating at a given static pressure by the motor horsepower (hp) rating. The problem with this ratio is that the horsepower rating of a motor is a measure of output power, rather than input power. Using horse power instead of watts to calculate fan efficiency does not account for motor efficiency, which can change with motor design and the degree of motor loading. Although this method tends to overestimate fan efficiency, it is still quite useful for comparison purposes.

For example, listed in *Table I* are cfm/hp values for five 24-inch diameter ventilation fans from one manufacturer. The nearly threefold difference in cfm/hp at static pressure levels typical of livestock building ventilation systems can result in significant differences in operating costs over the life of a structure and the fan. Also, higher horsepower fan motors typically run at faster speeds than smaller motors. Thus, for the same diameter blade, fans with small motors tend to be quieter than those with large motors.

Table I. Cfm per motor horsepower ratings for five 24-inch diameter ventilation fans from one manufacturer.				
Static pressure (in. H_2O)				
Horsepower	*0*	*0.10*	*0.125*	*0.25*
cfm/hp				
1/3	17,530	15,230	14,460	7,130
1/2	13,260	11,990	11,590	7,300
3/4	10,130	9,430	9,210	7,870
1	8,380	7,910	7,780	6,970
1 1/2	6,390	6,120	6,050	5,620

Listed in *Table II* are cfm/hp values for five fans with 3/4 hp motors from the same manufacturer. Efficiency tends to increase with increasing blade diameter, although at static pressures of 0.10 and 0.125 in. H_2O, the 42-inch diameter fan is the most efficient.

Table II. Cfm per motor horsepower ratings for five 3/4 hp ventilation fans from one manufacturer.				
Static pressure (in. H_2O)				
Diameter (in.)	*0*	*0.10*	*0.125*	*0.25*
cfm/hp				
24	10,130	9,430	9,210	7,870
30	13,500	12,440	12,080	7,640
36	16,990	14,350	13,600	N.R.
42	21,190	17,330	15,730	N.R.
48	24,130	17,070	13,840	N.R.
N.R. = Not rated at this static pressure				

The following "rules of thumb" can be used to help select an energy efficient fan when the system performance requirements are known:

- For a given airflow rate and static pressure, a large diameter fan is more efficient than a smaller one. The larger blades move more air per unit of energy input.
- For a given airflow rate and static pressure, one large fan is usually more efficient than a number of small ones.
- When two fans have the same blade diameter, the one with the lower horsepower or motor current input rating (motor full load amps or FLA listed on the motor nameplate) is usually more energy

efficient.
- If two fans have the same airflow and static pressure capabilities, the one with the slower speed motor is usually quieter and more energy efficient.

Efficiency ratings are a convenient way to compare two or more fans of different sizes that have similar air delivery and static pressure capacities, providing all fans meet the total system performance requirements. While fan efficiency is an important consideration, do not use it as the sole criterion to make purchasing decisions. Initial cost, parts availability, noise level, housing durability, ease of cleaning, and expected annual hours of operation are among the factors affecting long-term costs and serviceability. All of these factors, as well as efficiency, must be evaluated.

Certified Ratings

Good fan design and efficient performance are extremely important. The previously mentioned efficiency factors are primarily a function of fan design. To assure that a fan will perform in accordance with the manufacturer's literature, select only those fans bearing an Air Movement and Control Association (AMCA) "Certified Rating" seal. The air moving capacity of a fan bearing an AMCA seal, under conditions of the certification test procedure, will not be less than the manufacturer's advertised performance, although it may be greater. Field evaluations have shown that the capacity of many non-AMCA rated fans can be up to 50 percent less than the manufacturer advertises. An AMCA rating is the only way to assure you're getting the performance you're paying for.

Figure 4. AMCA "Certified Rating" seals.

In addition to certified ratings for air movement, many fans are also rated on the basis of noise production during operation, and some have cfm/W ratings. Each fan that is AMCA rated will bear a blue and gold seal, similar to those shown in *Figure 4*, on the fan housing.

Fan Maintenance

Keeping a fan and ventilation system in good repair is at least as important in reducing overall operating costs as buying an energy efficient model. Poor maintenance can reduce fan efficiency by 50 percent or more. Consult the fan owner's manual and/or dealer for specific cleaning and lubricating details. **Always remember to turn off the electricity at the circuit breaker, fuse box, or fan disconnect before servicing, washing/cleaning, or adjusting any fan or other electrical equipment**.

Ventilation system components require regular maintenance. This involves cleaning and adjusting thermostats, inlets, baffles, safety screens, shutters, and fans. Checking fan shutters is especially important during cold weather to be sure they do not become frozen in one position.

A dust buildup of 1/8 inch on fan blades and shutters can reduce fan performance by as much as 30 percent. Allowing dust to build up on safety grills or on the shutters so they do not open fully further restricts the fan's performance. Dirt built up on a motor acts as insulation, causing the motor to operate at elevated temperatures, a common cause of short motor life and premature motor burnout.

Use a vacuum cleaner to simplify cleaning of fans, shutters, and thermostats, and a stiff-bristled nylon brush to loosen stubborn dirt. A plastic windshield scraper is useful for removing heavy dirt buildup. Use caution when scraping the blades as harsh scraping can scratch them, causing imbalance and increasing corrosion.

Clean fan blades and shutters with a brush and detergent water. A pressure-washer can be used to clean the fan, housing, and weather hood, but be sure the fan has a totally enclosed motor housing so water and dirt cannot get into the motor windings. Even with a totally enclosed motor, electricity to the fan should be turned off before cleaning with water or a pressure-washer.

Use oil sparingly on fan and motor bearings. Too much oil attracts dust and soaks into motor windings.

Apply a few drops of antifreeze, graphite, or other non-oily lubricant on shutter hinges to reduce sticking in cold weather. Do not use oil, as this will quickly attract dust and become sticky.

Belt adjustment is one of the primary, and often overlooked, maintenance problems with belt-driven fans. These must be regularly adjusted if full air movement is to be achieved, and efficiency maintained. Therefore, belts should be easy to adjust. When a new fan or a new belt has been installed, the belt should be retensioned after two weeks of operation to take up the initial stretch. After this initial period of operation, the belt should be checked -- and adjusted if necessary -- on a monthly basis.

Check the electrical and thermal overload protection for the motor. If a time-delay fuse is used, its ampere capacity should be about 125 percent of the full-load amperage (FLA) shown on the nameplate of the motor. Larger sized over-current protection may permit motor burnout. If the motor is equipped with a reset-button overload protection, check that it is not stuck. *Caution: Motors with automatic reset thermal overload can start without warning. Turn off the power to the fan before reaching into the blades or belt*.

Check fuses for a tight fit, and fuses and sockets for signs of corrosion. To help assure proper operation, each month turn circuit breakers off and back on to break away any internal corrosion. Examine wiring and other electrical system components for signs of deterioration, loose connections, and rodent damage. Poor connections and/or corrosion result in greater electrical resistance, which can lead to overheating and increased potential of fire.

All wiring in agricultural buildings must use corrosion resistant, dustproof, and waterproof equipment. All motors must be totally enclosed, and an electrical disconnect is required within sight of, and not more than 50 ft. away from, every motor. Locating the shutoff in the immediate vicinity of the fan, or other motor, is recommended. Do not use plug and cord disconnects for permanently installed equipment unless waterproof cord ends are used. Simply plug- ging a fan or heater into a receptacle is not acceptable or safe.

Examine fan housings, frames, and weather hoods for dirt buildup and corrosion. After thoroughly cleaning, these items can be repainted with a rust and corrosion resistant paint to prolong their life. When ordering new fans, specify fiberglass, stainless steel, plastic, or epoxy coated housings.

Ventilation equipment needs periodic and routine maintenance to ensure efficient operation. Establish a service schedule for all components and keep a written record of when each service was performed. Failure to maintain the ventilation system in good condition can result in reduced quality of the environment in a livestock housing system or spoiled grain in a grain storage unit, and an increased cost per unit of air moved.

Summary

Many factors influence the efficiency of a fan. These include motor efficiency, blade speed, housing design, clearance between the fan blades and fan housing, and blade shape. However, even the most efficient fan will not perform satisfactorily if it is not kept clean and properly serviced. Of particular importance is keeping fan blades and shutters clean, shutter pivots and motor clean and lubricated, and drive belts properly tensioned and aligned.

For more information on ventilation fans, refer to NebGuides 95-1242, *Ventilation Fans: Performance*, and 95-1243, *Ventilation Fans: Types and Sizes*, available from the Cooperative Extension office serving your area.

*fpm = 0.26 x fan diameter (in.) x fan speed (rpm).

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