PRODUCT APPLICATION

A technical bulletin for engineers, contractors and students in the air movement and control industry

An Outline for Successful Fan Selections

This article outlines the considerations involved in properly selecting, applying, and controlling fans. Emphasis is placed upon matching the fan equipment to the system's requirements from several different perspectives. However, specific fan design and construction details are not within the scope of this article. An improperly selected and applied piece of equipment can be rendered completely ineffective if the application itself is not properly defined from the beginning. It is imperative to address every item listed in the following section.

Define the application

- What is the application and what is the required fan performance(s)?
- How many systems are there and are they interdependent?
- How many fans per system?
- Where is the fan equipment located (inside, outside, next to an office, on the ground, or several stories up in a building?) If outside, what are the ambient conditions?
- What space limitations exist? Is there adequate space for maintenance and removal of parts?
- What facility limitations exist in the form of weight, electrical capability, noise, or vibration?
- What fan orientation is best suited for the application?
- What fan arrangement is best suited for the application?
- Are there any minimum leakage concerns for the fan or ductwork?
- Are there any sound limitations including casing radiated or duct breakout noise?
- Are there any pre-installation storage requirements? If so, how long and under what conditions?
- The operating cost of electricity and any support functions required (power reliability; fan redundancy)?

Performance and system duty cycle

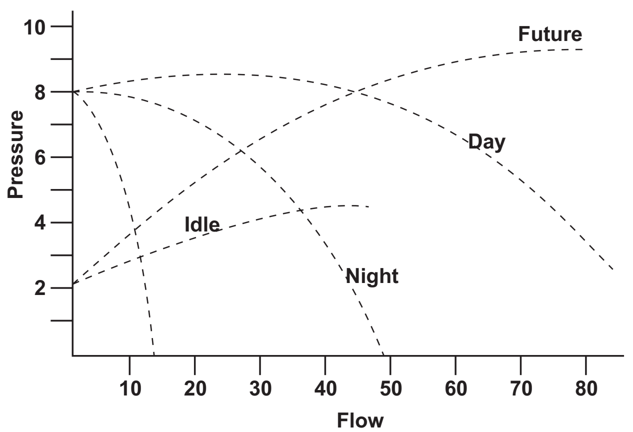
To analyze and make fan and control selections it is necessary to define the system duty cycle. All of the design and operating points must be defined and how long the system is required to operate at each point. This should include present as well as future design ratings.

The following information for each operating point is necessary:

- volume flow rate
- inlet and outlet static pressures
- temperature: design, operating, and rate of change
- gas composition if other than air
- gas contaminants considering erosion and corrosion
- elevation and barometric pressure or gas density
- single fan, fans in series or in parallel operation
- method of control.

It is also necessary to create a system duty cycle plot if several performance points are given. That is, plot all operating points on a single graph at a common density. By overlaying the fan performance curve information, it is easy to evaluate the basic fan selection along with the control characteristics. All operating points in the system duty cycle must fall within the fan's performance envelope. If any operating points fall outside of the envelope, those points will not be realized. This concept is illustrated in Figure #1.

Figure #1: System Duty Cycle



Life cycle considerations

The overall effectiveness of the fan/system selection should be evaluated by taking each of the following into account:

- **Initial cost** — What is the purchase price and cost of installation?
- **Operating cost** — What is the total cost per year to operate the fan, accessories, and any support equipment?
- **Maintenance** — Is maintenance costly and frequent? And, is the equipment accessible for ease of maintenance?
- **Frequency of repair and downtime** — What is the reliability of the equipment and the cost of downtime?
- **Spare parts** — Are spare parts expensive and readily available? Must an inventory of spare parts be maintained?
- **System availability** — What percentage of time must the system be operable? There may be the requirement to have a "stand-by fan" installed in the system or stored in Inventory.
- **Expected life** — What is the expected life of the equipment before it is to be replaced?

The basic fan selection

The fan type and its performance characteristics influence the basic fan selection. The fan and system must be compatible both structurally as well as from a performance standpoint. For any one performance point, there are many different fans which will satisfy that rating. However, based upon any one set of priorities such as fan size, efficiency, motor size, etc., there is only one best fan for that application. As an example, for a single operating point (design duty rating) of 25,000 cfm at 4.0 inches total pressure at a density of 0.075 lbs/ft^3 and 70°F, several different fans will satisfy that design duty rating. The possible selections are tabulated in the chart below considering impeller size, operating speed, horsepower, FEI (Fan Energy Index), sound, cost factor (relative selling price), and recommended motor size.

Depending upon which priority is chosen with regard to acceptability, the optimum fan selection will change.

Influence of fan size and type
25,000 cfm at 4" static pressure

Item	Axial	Mixed Flow			Backward Housed Centrifugal		
Dia (in)	40	33	36	40	33	36	44
Speed rpm	1770	1385	1119	938	1486	1104	770
Power bhp	29.7	27.4	25.6	25.3	29.1	26.4	22
Sones	88	40	33	28	51	45	31
FEI	1.09	1.25	1.26	1.23	1.17	1.22	1.36
Cost Factor	1.0	1.8	2.1	2.6	1.6	1.7	1.9
Motor (hp)	30	30	30	30	30	30	25

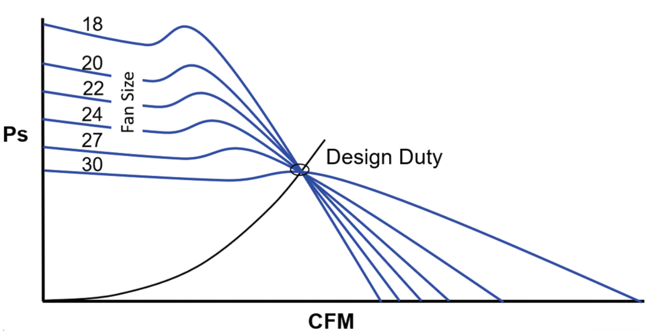
Based upon the cost factor (selling price) the 40-inch axial fan may be selected. However, this is a direct drive fan running at full synchronous motor speed with no capability for increased flow and pressure adjustment. Also, the sone level may exceed the application requirements.

Based upon operating cost, the 40-inch mixed flow or the 44-inch backward inclined housed centrifugal fan may be selected. Depending on the future flow and pressure requirements, the 36 or 40-inch mixed flow or the 36 or 44-inch centrifugal fans with increased motor horsepower may be selected to meet a future requirement.

Fan selection, design duty point, and efficiency

A fundamental concept is the relationship between fan size and the design duty (rating) point location on the fan curve. Why? Because larger fans are more efficient than smaller fans. Figure #2 shows generic performance curves for six different sized backward curved fans. This illustrates that the relative position of the design duty rating point on a specific fan curve changes location on the fan curve with a change in fan size for a specific design duty. As can be seen, all fan sizes each at their respective RPM curve meet the design duty (CFM, SP) required. However, the larger the fan the more the design duty point is further to the left of the fan curve approaching the fan curve peak and running at a lower RPM. The smaller the fan size used to satisfy the design duty rating, the faster it must run, and the design duty point is further to the right on the fan curve. In general, the smaller fan will be less efficient, acoustically louder, and because of its higher RPM prone to failing sooner.

Figure #2

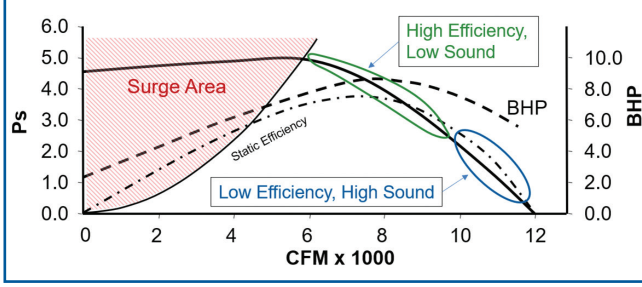


The table below is an example illustrating the fan power savings and the Fan Energy Index (FEI) for various fan sizes all applied at the same design duty point.

Fan Size in. (mm)	Fan Speed	Fan Power bhp (kW)	FEI
18 (460)	3,238	11.8 (8.8)	0.67
20 (510)	2,561	9.6 (7.2)	0.83
22 (560)	1,983	8.0 (6.0)	0.99
24 (610)	1,579	6.8 (5.0)	1.16
27 (685)	1,289	6.2 (4.6)	1.28
30 (770)	1,033	5.7 (4.3)	1.39
36 (920)	778	6.0 (4.5)	1.32

Restating, maximized efficiency of a fan selection occurs when the design duty is within the top two-thirds of the fan's RPM curve (high efficiency and low sound). This is the region where the static efficiency is the highest. Figure 3 illustrates the relationship between the fan curve, static efficiency curve, and the BHP curve. The understanding of this concept is also important when considering types of control and fan stability when the operation is near peak pressure.

Figure #3

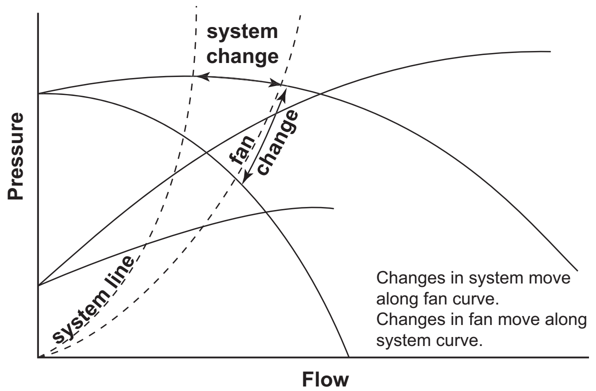


Fan control and moving the operating point

The following is intended to provide an understanding of the interdependence of the fan and its control with how effectively the system's performance envelope is satisfied. The fan control method is how the fan/system operating point (design duty) is manipulated in order to change the desired flow/pressure somewhere else in the system. If you change the system resistance, the operating point will move along the fan curve. Fans equipped with an outlet damper, an opposed bladed inlet box damper, or a system damper are examples. If you change the fan performance capability, the operating point will move along the established system resistance curve.

By having the ability to adjust both the system and the fan performance, the operating point can be moved to almost any desired position under the fan curve. This is illustrated in Figure #4. Controls that move the operating point along the system curve include variable inlet vanes, parallel-bladed inlet box dampers, blade angle changes on axial fans, and the many techniques used to change the fan speed. It is extremely important to know the individual performance characteristics of each type of fan control.

Figure #4: Moving the Operating Point



Fan control criteria

Having the ability to move the operating point creates a whole new set of considerations. These range from performance to physical equipment limitations. Most of these considerations are listed below. Depending upon the installation, some are more important than others; however, all should be considered.

- Turndown/leakage
- Sensitivity to change/stability/transients
- Repeatability
- Reliability
- Efficiency expected
- Sound considerations
- Structural considerations
- Environmental considerations
- Interface considerations for computer control

Summary

This article has attempted to outline the major considerations that should be included in any fan and fan control selection. This content can be used as a checklist or a reminder of key items to consider in selecting and applying fans. It does not guarantee a successful application but can contribute to eliminating many of the common problems associated with collecting and analyzing required information early in the fan selection process. A detailed explanation of FEI (Fan Energy Index) is presented in Greenheck's technical bulletin FA/03-23.

Regarding the accuracy of a fan manufacturer's performance data, The Air Movement and Control Association International, Inc. (AMCA) establishes industry-accepted test standards for fans and allows a manufacturer to participate in certified ratings programs for the aerodynamic and acoustic performance of fans.

AMCA Certified Ratings

A manufacturer that participates in AMCA's Certified Ratings Program (CRP) assures the industry that the products and equipment will perform as stated by the manufacturer. The program stipulates the various rules and regulations for presenting cataloging data: AMCA 211 for aerodynamic performance and AMCA 311 for acoustic performance.