

Selecting Efficient Fans

By John Murphy, Ph.D., Member ASHRAE

For much of the past 50 years, HVAC system design and fan selection decisions were driven more often by first, rather than life-cycle, cost. This was due primarily to the low price of energy. Even when life-cycle cost comparisons were made, the projected energy costs were artificially low by today's standards. The large number of speculative buildings constructed heightened the trend. Recent events have shown the need to rethink our philosophy about using first cost as the deciding factor for system design and fan selection.

Because the need to supply ventilation will not disappear, the required ventilation will need to be supplied at the lowest possible total cost, accounting for the impact of lower velocities on duct (and, therefore, building) size, the initial cost of the fan and associated components and the power consumed over the life of the system. It is clear that there must be significant pressure to use the most efficient components, especially the fans and motors.

High efficiency motors are already being required by most building authorities. Improving the efficiency of fans is now the focus of a concerted effort, both in the United States and worldwide. Standards are being written defining fan efficiency grades (FEG) and fan/motor efficiency grades (FMEG). Although these efforts are not yet complete, it is clear that these definitions will soon become available to aid in selecting high efficiency fans.

The Air Movement and Control Association International (AMCA) has developed a standard (AMCA 205-10) that defines fan efficiency grades (FEG) based on the peak value of total efficiency of the fan without consideration of the motor/drive. This standard also recommends that any specification or code that sets a minimum acceptable FEG also include a requirement that the efficiency at the actual operating point(s) be within 10 points of the peak value.

The next revision of Standard 90.1 is expected to set a minimum FEG grade for fans used in non-residential buildings. It is clear that the current direction is toward setting minimum fan efficiency levels. Before discussing the impact this may have on fan manufacturers, let us look at some performance data.

The peak efficiency that can be achieved in any fan is a function of fan type and size. *Table 1* shows values of peak total efficiency achievable by production units with diameters of 24 in. (600 mm) or greater. The values in this table were generated from a thorough review of published catalogs from many U.S. and European Union manufacturers. Although the reduction in

Fan Type		Peak Total Efficiency %
Centrifugal	Airfoil	88
	Backward Curved	84
	Backward Inclined	80
	Forward Curved	70
Axial	Vane Axial	86
	Tube Axial	75
	Propeller	55
Mixed Flow		75
Tangential		25

Table 1: Peak total efficiency by fan type.

efficiency at smaller sizes is significant, the relative ordering by fan type is basically unchanged. There may be fans produced that exceed the values in *Table 1* by a small margin (one or two points of efficiency) in any fan type. The variation in peak efficiency with fan type can be understood by considering the differences in the details of the various designs. In general, the more efficient fan types are more expensive to manufacture than the lower efficiency types.

The factors that affect efficiency of centrifugal fans are blade profile, wheel width, inlet to wheel clearance and cutoff height. For axial fans, the important factors are blade profile, tip clearance and swirl recovery. Some fan types have inherent advantages or disadvantages due to their configuration.

As an example, a forward-curved centrifugal fan cannot achieve peak efficiencies close to those achieved by any backward-oriented blade design because the forward-curved blade guarantees separated flow (locally) downstream of the blade, and this separation causes a loss of energy. The backward-oriented designs rank in efficiency order according to the aerodynamic quality of the airflow passage through the impeller; curved blades are better than flat blades and airfoil shapes are better than single thickness. For axial fan types, propeller fans suffer from larger tip clearances and the absence of turning vanes and tube axial fans suffer from the lack of turning vanes.

The values in *Table 1* suggest that as minimum FEG grades are specified there will be considerable pressure to restrict the use of (at least) forward-curved and propeller fans.

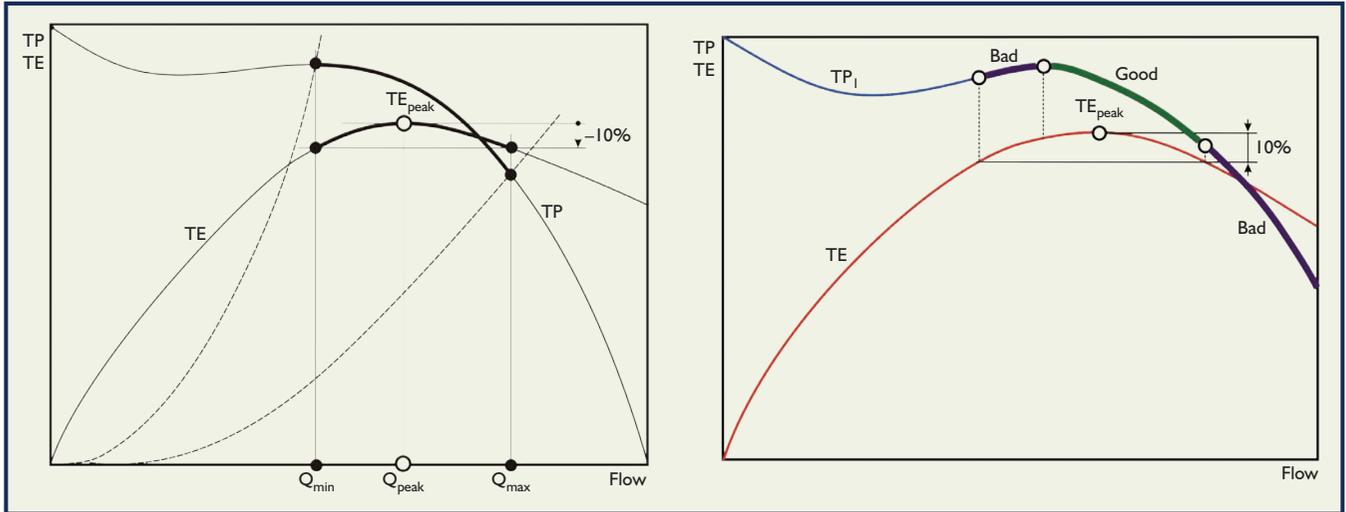


Figure 1 (left): Selection range with no instability. Figure 2 (right): Selection range with possible instability.

The operating point(s) of the fan must also be kept close to the peak efficiency point if the power consumed is to be kept to minimum values. Unfortunately, past practices often have been to use a small fan running at a higher speed due to cost pressures, both in the building and the fan. This usually means the fan is operated far to the right of peak efficiency. Figure 1 illustrates the portion of the fan curve where all operating points should be located. Unfortunately, not all fans have a continuously rising pressure curve at all flows between peak efficiency and peak efficiency less 10%. Figure 2 depicts such a case. Some (and probably most) fan types exhibit instability when operated in this region of positive slope in the pressure-volume curve.

The method used to provide part-load performance is critical for any application where the system resistance varies significantly. The most commonly used method is adjustable frequency drives, which allow fan speed variation. The turndown available may be limited because the system resistance is not a constant orifice (i.e., the pressure varies as the flow is squared) since the VAV boxes require a minimum pressure to operate, and there is a minimum speed, which must be achieved to satisfy the boxes. Variable inlet vanes can also be used but there will be an efficiency penalty and turndown will be limited. Axial fans with variable geometry (blade angle change during rotation) are also available, and may be the solution of choice for systems with wide diversity (pressure does not follow flow squared).

Retrofits present a more difficult problem than new construction since space may not be available to use fans of higher efficiency without major modifications.

Although widespread agreement exists that energy use must be reduced, it is still unclear whether the architects, mechanical designers and building operators will make energy reduction the primary consideration in design, selection and operation. In this writer's opinion, it may be

necessary for code authorities to take the lead in reducing energy use.

John Murphy, Ph.D., is a principal of JOGRAM, Inc., in New Philadelphia, Ohio. He retired as engineering manager of Joy Technologies (formerly Joy Manufacturing) Fan Division. ●

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