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Codes & Standards

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PRODUCT APPLICATION GUIDE

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

Understanding Fan Efficiency Grades (FEG)

Government agencies and regulatory bodies in the U.S. and around the world are working on regulations to help reduce power consumed by fans in commercial and industrial ventilation. As a part of this effort, an efficiency metric known as Fan Efficiency Grade (FEG) was developed by AMCA International* (in support of a request from ASHRAE** Standard 90.1) that could be used to establish minimum acceptable fan efficiency. This paper will define the Fan Efficiency Grade metric, explain how FEG ratings are determined, and review key limitations of the FEG metric.

FEG Definition and Rating

FEGs, as defined in AMCA 205, are designed to be a simple system to indicate the aerodynamic quality of the fan and are based on the fan's peak total efficiency. The total efficiency is calculated using the traditional airflow, pressure, and input power as measured per AMCA Standard 210. It does not take into effect the efficiency of the drive (belt drive) or the motor. Fan efficiency is defined as the air power divided by the fan input power. Both Static and Total Efficiency can be calculated from fan performance data as follows:

$$\text{Static Efficiency (SE)} = \frac{\text{CFM} \times P_s}{6343 \times \text{BHP}}$$

$$\text{Total Efficiency (TE)} = \frac{\text{CFM} \times P_t}{6343 \times \text{BHP}}$$

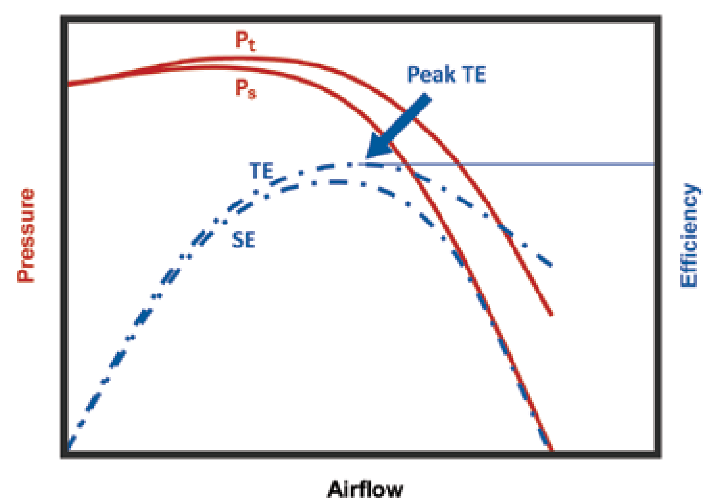
Where:

CFM = Fan flow rate, ft^3/min
P_s = Static pressure, in. wg
P_t = Total pressure, in. wg
BHP = Fan power input, hp

Static and total fan efficiency (*Figure 1*) can be plotted along with the fan curve. The peak total efficiency occurs at the top of the "bell" shaped efficiency curve. This peak efficiency is used to determine the FEG value.

Note that the peak efficiency occurs at just one point on the curve and all other points on the curve have a lower efficiency. It is important to understand, as the efficiency curves illustrate, that each fan has a large range of efficiencies depending on the airflow and pressure of the operating point. For example, a fan with a peak efficiency of 70% can easily be selected to operate at a point of only 50% efficiency.

Figure 1



Another aspect of AMCA FEGs is that their value depends on the fan size. Smaller fans are inherently less efficient than larger fans. This is because the smallest dimensions — material thicknesses and

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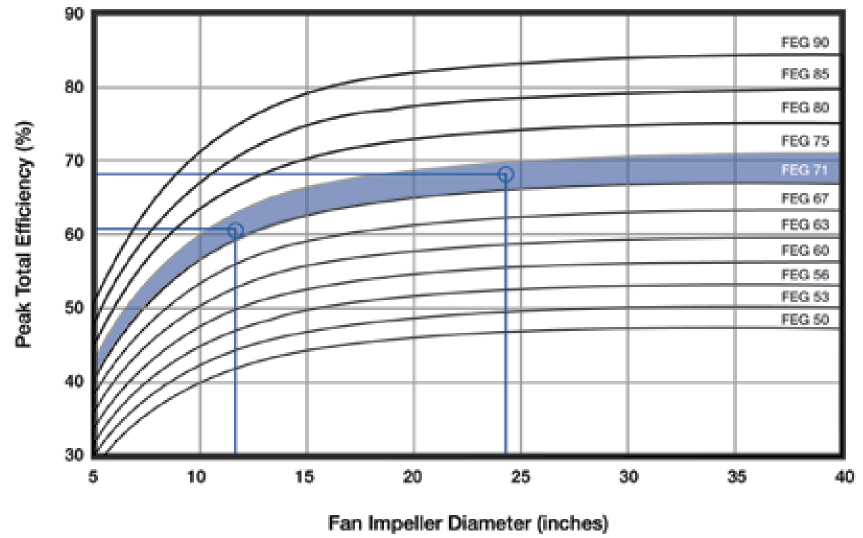
running clearances between parts — cannot be held as tightly in proportion to other dimensions as they can on larger fans. The AMCA FEG curves have been established such that fans of a given model that are geometrically similar will each have the same, or nearly the same, grade.

Once the Peak TE is known, the FEG value can be determined from AMCA Standard 205-12. (*Figure 2*) For example, a 24.5-inch diameter fan with a Peak TE of 69% would be classified as an FEG71. *Note that a 12-inch diameter fan with a Peak TE of 60% is also FEG71.*

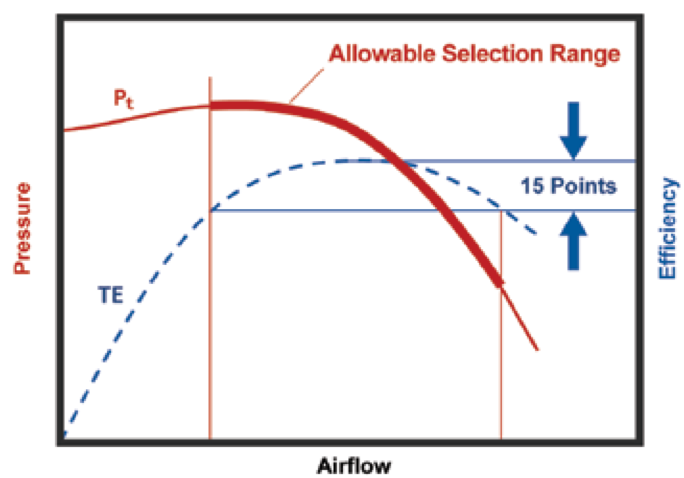
Figure 2



Selection Range

Because the efficiency curve of a fan is bell shaped, specifying a relatively high FEG by itself will not necessarily result in high fan efficiency. To realize the potential efficiency of a fan, the fan must operate near its peak efficiency. AMCA Standard 205 recommends that all selections be made within 15 percentage points of the Peak TE. This requirement effectively reduces the allowable selection range as shown in the fan curve shown in Figure 3.

Figure 3



Limitations of FEG

A significant shortcoming of the FEG metric is that the highest FEG fan does not necessarily result in the lowest energy consumption. Table 1 below illustrates this point. Notice that the 72-inch fan requires the least energy (lowest BHP). Yet, the 48-inch fan has a greater total efficiency (66% vs. 60%) and a higher FEG (71 vs. 63).

So how can the fan with a higher efficiency consume more than twice the power?

First, the FEG is based on fan **total efficiency** and fan total pressure. Total pressure is used because it is a measure of the total energy imparted to the air. However, the velocity pressure exiting a fan can only be used when it is contained in a duct –

Table 1 Sidewall Propeller Fans Selected for 40,000 CFM at 0.125 in. wg

Diameter	RPM	PS	PV	PT	BHP	SE	TE	Peak TE	FEG
48 inches	638	0.13	0.60	0.72	6.91	11%	66%	67%	71
54 inches	488	0.13	0.37	0.49	5.81	14%	54%	55%	56
60 inches	346	0.13	0.24	0.36	3.93	20%	58%	59%	60
72 inches	260	0.13	0.13	0.25	2.63	30%	60%	60%	63

and is lost on non-ducted fans. This makes FEG an inappropriate and often misleading metric for many fan applications, such as sidewall propeller fans, powered roof ventilators (PRVs) and plenum fans. For fans without a discharge duct, static efficiency will correlate to power consumption.

Note: In the example in table 1, the 48-inch fan has a much greater discharge velocity than the 72-inch fan. This contributes to the high TE and FEG values, but since this is a non-ducted application, the velocity pressure is lost. Notice that the 72-inch fan has the highest static efficiency which is the proper metric for nonducted applications.

Second, as communicated earlier, the FEG value is based on the **peak efficiency** of the fan. For a given point of operation (CFM and pressure) an FEG63 fan could consume less power than an FEG75 fan simply because it is selected closer to its peak efficiency point. Fans with higher peak efficiencies do have a greater *potential* to operate more efficiently. However, the actual fan efficiency as selected is the correct measure of actual energy consumed.

Another limitation is that while specifying a **single FEG value** for all fan applications would be desirable, it is just not that simple. The current direction is to use a minimum FEG67 in ASHRAE Standard 90.1 and the International Energy Conservation Code (IECC) for all fans. Yet, it is well known that weather guarding of PRVs inherently impacts fan efficiency negatively. And as discussed above, PRVs and other fans with a non-ducted discharge should not be held to the same metric that is based on ducted total efficiency. To accommodate these realities, several exemptions have been added to the proposed language so that the industry doesn't unwittingly eliminate economical and efficient fans from existence. Meanwhile, ducted housed airfoil centrifugal fans and ducted vane axial fans already greatly exceed the proposed minimum value of FEG67, so this won't drive greater efficiency for these fans. The end result is that the single FEG value approach as proposed in ASHRAE Standard 90.1 has little ability to actually save energy.

Conclusion

FEGs are a simple measure of the peak total efficiency of a fan. Although other alternatives are being considered for code regulation and energy savings, FEG was initially incorporated into proposed code language and has not been replaced (as of the time of this writing). Because of the current state of events on this front, the final code language may use FEGs to establish minimum aerodynamic efficiency levels. If this occurs, fans below the mandated FEG value will not be allowed.

Regardless of the outcome of code language, FEG is a poor metric in determining the most efficient fan (in terms of actual power consumption) for a given airflow and pressure operating point. Clearly the best simple metric to ensure the lowest power consumption is the operating BHP at the specified design point. From a specifying engineer's perspective, there are really two key take-away points regarding fan efficiency:

1. Specify the specific **operating BHP** in your fan schedule AND specify that fans are licensed to bear the AMCA seal for air performance. This ensures that your fan application performance / energy intent is met.

2. When the code language is finalized, reputable manufacturers will continue to provide information and tools to help you comply with the minimum code requirements. And in many cases, economical products will be available that exceed the code minimum.

*AMCA International, Air Movement and Control Association, International

**ASHRAE, American Society Heating Refrigeration and Air Conditioning Engineers

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