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AMCA's Fan Efficiency Grades:

Answers to Frequently Asked Questions

Learn what FEGs are and how they are applied for HVAC systems in commercial and industrial buildings. It has become clear that fan system design improvements and higher efficiency fans could have substantially reduced HVAC energy use in commercial and industrial buildings. Until recently, fan selection guidance and metrics that allow quick comparison of fan efficiencies have not been available. One approach has been to specify a fan efficiency rating based on the aerodynamic properties of the fan itself, and to specify where on the fan efficiency curve the fan operation point should sit.

In essence, this is what AMCA International, working with ASHRAE's TC 5.1 fan committee, has done with the development of a new fan efficiency classification system, called the Fan Efficiency Grade (FEG).

Work that began in 2007 to address fan efficiency classifications is now paying off. FEGs were formalized with the publication of AMCA 205 in 2010, and an AMCA Certified Ratings Program is now in place to provide third-party verification of FEGs as specified in AMCA 211.

This article answers questions that engineers, building owners, operators, regulators, and contractors may have about FEGs.

What is a Fan Efficiency Grade?

A fan efficiency grade (FEG) is a numerical rating that classifies fans by their aerodynamic ability to convert mechanical shaft power, or impeller power in the case of a direct driven fan, to air power. Essentially, it reflects fan energy efficiency, allowing engineers to more easily differentiate between fan models: more efficient fan models will have higher FEG ratings. FEGs apply to the efficiency of the fan only and not to the motor and drives. FEG ratings can be applied to custom-built single fans and to series-produced fans manufactured in large quantities.

In 2007, the ASHRAE Standing Standard Project Committee (SSPC) 90.1's, mechanical subcommittee, invited ASHRAE TC 5.1, Fans, to participate in the development of the requirements for fan efficiency. An ad hoc working group was formed promptly. With assistance from the AMCA Fan Committee, the group first developed a system for energy-efficiency classification of fans. The group recognized that a highly efficient fan will operate inefficiently if used in the low-efficiency region of the fan curve. This led to a requirement that fans be specified within 10 percentage points of the peak total efficiency (Figure 1).

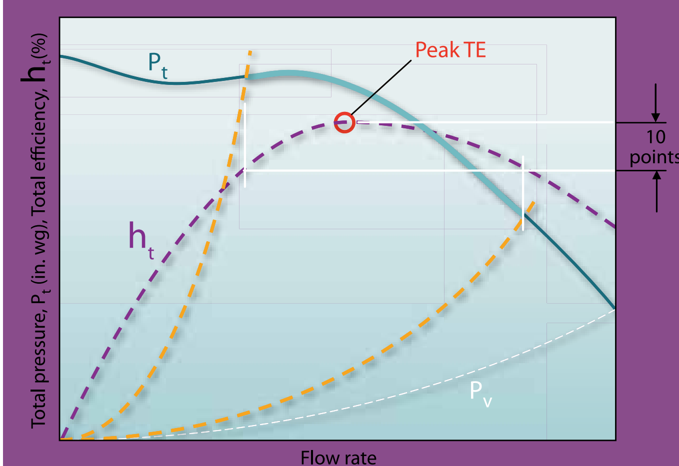

Figure 1: A typical fan curve showing the 10-point total efficiency band.

FEGs were developed by AMCA in response to regulators in the U.S. and abroad taking interest in reducing fan energy consumption and the environmental impacts of that consumption. Simultaneously, the International Standards Organization (ISO) was considering a similar efficiency rating for European energy standards and regulations.

For the U.S. market, where fans are normally cataloged as bare-shaft fans and purchased with standard NEMA motors, FEGs were defined through AMCA Standard 205-10, *Energy Efficiency Classification for Fans*. AMCA Publication 211, *Product Rating Manual for Fan Air Performance,* describes the certification process for rating a fan for FEG.

For the European Union, where fans are often packaged with integral motors, ISO Standard 12759-2010, *Efficiency classification for fans,* defines fan-motor efficiency grades (FMEG). Note that these two grades are not equivalent and in no circumstances should FEG and FMEG be used simultaneously to evaluate fan performance.

What are FEGs used for?

FEG ratings are used by code authorities or by specifying engineers to define a minimum requirement for energy efficiency of a fan for a given application. The specifications can use a single-value FEG for each application.

The use of a single number is possible because the shapes of the FEG bands closely follow the actual peak efficiencies for typical fan designs (Figure 2). Smaller fans are typically less efficient than larger fans for a given fan type, and this trend is reflected in the shape of the efficiency bands. Rather than making individual fan selections to determine a minimum efficiency target for each duty point, the specifying engineer can simply establish a minimum FEG for the application (i.e., FEG71 for all supply fans, FEG67 for all exhaust fans, etc.). Minimum FEGs can also be adopted by energy codes and standards, such as ANSI/ASHRAE/IES 90.1, *Energy Standard for Buildings Except Low-Rise Residential Buildings,* and the International Code Council's *International Green Construction Code* (IGCC).

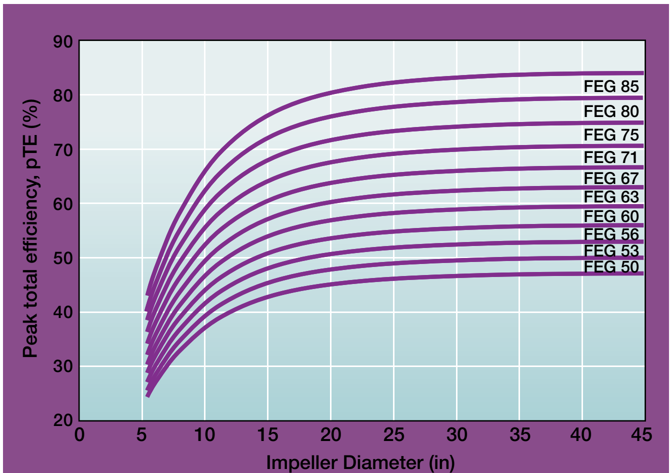

Figure 2: FEGs for various fan efficiencies and sizes.

How are FEG ratings calculated?

FEGs are based on peak total efficiency for a given fan size. The FEG is established by plotting the peak total efficiency at the appropriate impeller diameter, then reading the associated FEG band in which this point falls. For example, a fan with an impeller diameter of 15 in. and a peak total efficiency of 71% would have an FEG of 80 (Figure 3).

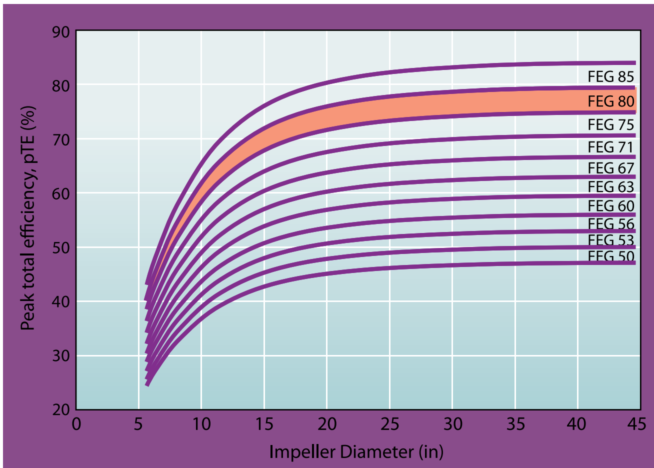

Figure 3: FEG band area for FEG80.

Annex A to AMCA 205-10 provides equations for the upper and lower boundaries of each fan efficiency grade, as well as a table of peak fan total efficiency versus fan size that can be used to calculate the FEG.

Engineers and other practitioners, however, will not have to calculate FEGs; they will find them in manufacturers' literature and software as they become available. AMCA-certified FEG ratings for fans will be identified in search results from the AMCA certified product database at www.amca.org/certified.

Which fan types and sizes are covered, and which ones are not?

AMCA 205 and AMCA 211 have slight differences with respect to minimum fan sizes, and there are a few other differences as well, as shown in Table 1. AMCA 205 is currently being revised, after which it will be harmonized with AMCA 211.

When codes and standards set FEG requirements, they will specify FEG ratings, fan sizes, and exclusions. For example, ASHRAE 90.1 is using FEG67 as its minimum FEG rating, and for fans above 5 hp; and there are a number of exclusions beyond those named in AMCA 211.

Table 1: Differences in AMCA FEG standards 205-2010 and 211-2011. **Exclusions are listed in the Certified Ratings Program in AMCA 211 because their primary purpose is not to move air, there is no standardized method to determine their fan total efficiency, or their primary function is life safety.*

STANDARD	YEAR	MIN. SIZE	MAX. SIZE	MIN. ANNUAL ENERGY	EXCLUSIONS*
AMCA 205	2010	1/6 hp (125 W)	None	1,000 kWh	None (this will change)
AMCA 211	2011	1 hp (750 W)	None	None	Air curtains; induced flow fans; energy recovery ventilators (heat recovery ventilators); positive pressure ventilators

The IGCC is considering FEG71 as a minimum threshold for fans at or above 1 hp. The IGCC, which is a "reach code" adopted by organizations looking for "beyond code" building energy performance, is scheduled to release Version 1 of the code in 2012. The IGCC requirement is proposed for the prescriptive section of the code, which is applicable for buildings up to 25,000 sq ft.

For the most up-to-date information on AMCA 205 revisions and matching to 211, visit www.amca.org/feg.

How do I consider FEG ratings in my projects when sizing, selecting, and specifying fans? What about fan systems, that is, fans with motors and drives?

Once an engineer has narrowed the list of available fans to only those that meet the minimum FEG rating as specified, the focus should be on actual power consumed. Since FEG ratings are a measure of peak fan energy efficiency and not actual operating efficiency, their main value is in differentiating between different fan types.

For a given duty (flow rate and pressure), several fan types and multiple fan sizes may be considered. When making fan selections, the list of available fans is first checked to ensure they meet the minimum FEG requirement. This means they must meet the required peak total efficiency but also must be selected within 10 percentage points of this peak. After that, the refined list of fans is compared using first cost and operating cost, and any other parameters, such as sound, physical size, and so forth. The actual fan input power becomes the basis for the operating cost used in a payback, ROI, or other economic analysis that can be used to compare annual and lifecycle costs for different fan types and sizes:

From Table 2, note that eight fans are physically capable of the performance required, and each of these fans happens to have the same FEG rating. The smallest three fans are not selected within 10 percentage points of the peak efficiency. These fans would operate near the bottom of their fan pressure curves; therefore, they would not meet Standard 205 and would not be considered for this duty. The remaining fans sizes, which range

TABLE 2 PRESENTS AN EXAMPLE OF FAN SELECTIONS USING FEG AND PEAK TOTAL EFFICIENCY RATINGS.

Table 2: Fan selection example using single-width, single-inlet (SWSI) fans with ducted outlet and 10,000 cfm at 3-in. Pt. *Total efficiency for these selections is not within 10% of peak efficiency.

FAN SIZE (in.)	FAN SPEED (rpm)	FAN CLASS	FAN POWER (bhp)	ACTUAL STATIC-EFFICIENCY	ACTUAL TOTAL EFFICIENCY	PEAK TOTAL EFFICIENCY	FEG	INLET LwA
18	3238	III	11.8	18%	40%	78%	85*	103
20	2561	II	9.56	30%	49%	78%	85*	100
22	1983	II	8.02	44%	59%	79%	85*	96
24	1579	I	6.84	57%	69%	79%	85	90
27	1289	I	6.24	67%	76%	79%	85	88
30	1033	I	5.73	76%	82%	83%	85	84
33	887	I	5.67	79%	83%	83%	85	84
36	778	I	6.01	76%	79%	83%	85	83

from 24-in. to 36-in., could be considered using their actual brake horsepower (bhp) and other selection criteria.

As mentioned earlier, FEG ratings apply only to the fan efficiency and not to the motor and drives. Adding motors and drives to the selection process is partially a matter of complying with national energy regulations. The National Electric Manufacturers Assoc. (NEMA) established Premium Efficiency specifications for motors that were adopted into federal regulations via the U.S. Energy Independence and Security Act (EISA). EISA specifies minimum full load motor efficiencies; for example, a 7.5 hp open motor on the above fan selections has a minimum motor efficiency of 91.7%.

Accounting for drives begins with determining whether the fan will be driven directly or through a V-belt. V-belt drive losses vary considerably with power transmitted, type and number of belts, pulley diameters, tension, and so on. AMCA Publication 203, *Field Performance Measurement of Fan Systems,* has a chart of the typical range of losses for V-belt drives as they relate to power transmitted. The average drive losses range from around 9% for a 1 hp drive to around 4% for 50 hp and higher. Said another way, the drive efficiency would range from around 91% for a 1 hp drive to around 96% for 50 hp and higher. Note that direct driven fans do not encounter these drive losses and, therefore, have an effective drive efficiency of 100%. Direct drive fans should, therefore, be used whenever possible and especially on smaller fans. For the 7.5 hp drive on the above fan selections, the drive loss is estimated at 6% or 0.45 hp.

Variable frequency drives have some internal losses and also cause a slight decrease in motor efficiency. The combined effect is small, approximately 3% to 5% loss. However, their advantages in allowing fans to respond to system requirements and run at reduced speeds far outweigh these losses.

The following is an example of an energy analysis comparing a 24-in. SWSI fan to a 33-in. fan at 10,000 cfm at 3-in. total pressure. The fan operates 16 hours per day, and the electric rate is $0.10 per kW-hour. For simplicity, a VFD is not considered:

Size 24:
Total mechanical power = 6.84 fan shaft bhp + 0.45 hp drive loss = 7.29 hp

Total kW into motor = 7.29 hp × 0.746 kW/hp/ 91.7% motor efficiency = 5.93 kW

Total annual cost = 5.93 kW × 16 hours/day x 365 days/year × $0.10/kW-hour = $3446

Size 33:
Total mechanical power = 5.67 fan shaft bhp + 0.45 hp drive loss = 6.12 hp

Total kW into motor = 6.12 hp × 0.746 kW/hp/ 91.7% motor efficiency = 4.98 kW

Total annual cost = 4.98 kW × 16 hours/day × 365 days/year × $0.10/kW-hour = $2,908

Annual Savings = $3,446 – $2,908 = $538

What codes or standards refer to FEG ratings?

As mentioned earlier, FEGs (and FMEGs) were developed to facilitate regulatory measures that seek to increase fan and fan system efficiency.

AMCA 205 is currently being considered for adoption in an advisory "continuous maintenance proposal" into ANSI/ASHRAE/IES 90.1-2010. It also is on the path to being adopted into the prescriptive requirements of the IGCC. For more information on these two developments, see related article, "Update on Fan Efficiency Grade Option into ASHRAE 90.1 and the International Green Construction Code." AMCA is reporting progress on AMCA FEG standards and where they are adopted into codes and standards at www.amca.org/feg.

If I want to replace my existing fan with a new fan that has an FEG rating, how do I calculate energy savings?

Fan replacement is treated in much the same way as a new installation. If required by code, the replacement fan must meet a minimum FEG rating and be selected within 10 points of the peak fan efficiency. The economic analysis would then be done using actual energy savings of the new fan over the existing fan. Replacement fans present some challenges in getting the new fan to fit in the same overall space as the old fan and physically moving the new fan into this location. Unfortunately, this is made even more difficult when trying to use a larger, more efficient replacement fan.

However, the newer fans and fan systems result in energy (and economic) benefits beyond the fan efficiency. Not only can the actual fan efficiency be improved, older belt driven fans can be converted to direct driven fans with higher efficiency motors. Variable frequency drives can also be added to turn back fan speed during off-peak demand times.

Do FEGs relate to sound performance or other fan-performance parameters?

Fans, like many other machines, produce the least sound when they are operating most efficiently. This relates to FEG ratings in two ways. First, FEG ratings are a measure of peak total

Figure 4: AMCA Certified Rating Program seals for air performance and FEG.

efficiency. With more shaft power being converted to usable aerodynamic power, less power is wasted creating heat and unwanted sound. For this reason, a fan with a higher FEG rating will generally have lower sound levels, all else being the same.

Second, fan sound varies considerably along a fan curve. Generally speaking, the most efficient part of the fan curve coincides with the quietest operation of the fan. As the operating point moves up or down the fan curve, sound is typically increased. By requiring the fan selection to be within 10 points of the peak fan efficiency, the louder parts of the fan curve are avoided altogether.

Where do I find FEG ratings?

Because the AMCA 211 standard was only recently updated to include the FEG certification program, there are no "certified" FEG ratings at this time. However, FEG ratings can be calculated from other fan performance data, as described above. Over time, FEG ratings will be included in manufacturers' catalogs, software, and data sheets. Fans that have FEG ratings will display a green AMCA certified rating seal; AMCA-certified fans that do not have an FEG rating will display a blue certified ratings seal (Figure 4).

There are three different types of certified FEG ratings, each with a distinct seal. The generic "FEG" seal, shown in Figure 4, can be used in a catalog when not all sizes in a licensed product line are "FEG" certified. If all sizes are "FEG" certified, then either the "Sound, Air Performance and FEG" or "Air Performance and FEG" seals may be used in the catalog.

Suggested Reading

The following articles are available at www.amca.org/feg:

"The Role of Fan Efficiency in Reducing HVAC Energy Consumption," by Michael Brendel, PhD. *AMCA inmotion,* April 2010.

"Fan Industry Meeting Energy Challenges," by Joe Brooks, PE; John Cermak, PhD, PE; and John Murphy, PhD. *AMCA inmotion,* April 2009.

"Select Fans Using Fan Total Pressure to Save Energy," by John Cermak, PhD, PEng; and John Murphy, PhD. *ASHRAE Journal* July 2011.

"New Fan Standard for Energy Efficiency," by Mike Duggan. ISO Focus, October 2009. Note: Pertains to ISO 12759 and FMEG.