Fan Efficiency Requirements For Standard 90.1-2013

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Although fans have been used in their current form since Georgius Agricola described their applications for ventilating mines in 1556,[1] it wasn't until 2007 that explicit requirements for minimum fan efficiency in energy and construction codes began to take form. The pace has accelerated since then for developing a means and metrics for determining and expressing fan efficiency, and developing explicit energy efficiency requirements for fans in commercial and industrial applications.

ANSI/ASHRAE/IES Standard 90.1-2013 is the most recent national code or standard to adopt AMCA 205, *Energy Efficiency Classification for Fans*, which was first published in 2010. AMCA 205 was updated in 2012 and certified by ANSI.[2] To date, AMCA 205 is referenced by one model construction code (2012 International Green Construction Code[3] [IgCC]) and one model energy code (ANSI/ASHRAE/IES Standard 90.1-2013[4]).

By 2015, fan efficiency requirements will likely be in all U.S. model energy and construction codes. With U.S. fan-energy consumption in commercial HVAC systems estimated to be around 1.25 quads (1.32 EJ) annually,[5] the U.S. Department of Energy Appliance and Equipment Standards Program has initiated the development of a federal efficiency standard for commercial and industrial fans, blowers, and fume hoods.[6]

This article describes the fan efficiency requirement within Standard 90.1-2013, and AMCA 205. The article begins with a brief history of the development of fan efficiency standards in the U.S. and Europe, and concludes with an outlook for future fan efficiency requirements in the U.S.

Brief History

The development of fan efficiency classification standards is a story of international collaboration leading to separate but harmonized standards. In 2007 and 2008, committees, subcommittees, and working groups within ASHRAE, Air Movement and Control Association (AMCA) International, and the International Standards Organization (ISO) began to work separately and collaboratively to develop means to classify fan efficiency, and to draft language for insertion into codes, standards, and regulations for energy efficiency and green/high-performance building construction.

ISO published Standard 12759 *Fans—Efficiency classification for*

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fans[7] in 2010 and AMCA International published Standard 205 in the same year. The AMCA standard focuses on defining a fan efficiency metric, called a fan efficiency grade (FEG) based on the aerodynamic quality of the fan separate from its motor and drive. The ISO standard has a harmonized definition of FEG, but also defines a metric that includes the motor/drive assembly, i.e., fan motor efficiency grade (FMEG).

In 2011, the European Commission published the fan efficiency regulation, (EU) No. (327)/2011 that internalized sections of ISO 12759 that apply only to motorized fans using the FMEG metric, with modifications.[8] EU 327 took effect on Jan. 1, 2013 with initial efficiency requirements. In 2015, a second, more stringent, tier of efficiency requirements will take effect. For more information about (EU) 327/2011, visit www.amca.org/feg/fmeg.aspx. The remainder of this article covers AMCA Standard 205 and U.S. fan efficiency codes and standards.

In the U.S., the 2012 International Green Construction Code adopted AMCA 205-10 for expressing fan efficiency requirements for supply, return, and exhaust fans greater than 1 hp (750 W) for buildings less than 25,000 ft^2 (2323 m^2). The requirement has a minimum FEG rating of 71, and a fan sizing/selection window of 10 percentage points from peak total or static efficiency.

Earlier versions of Standard 90.1 had some fan efficiency requirements through the section on "fan power limits." However, this section primarily limits fan energy consumption through static efficiency requirements on air distribution systems. It did not encourage manufacturers to produce more efficient fans.[9] Explicit fan efficiency requirements were adopted in Standard 90.1-2013 through ASHRAE's continuous maintenance process as Standard 90.1-2010 Addendum *u*. Addendum *u* underwent an advisory public peer review in 2011, and a conventional public peer review in 2012.[10] The final language is shown in the sidebar, *Fan Efficiency Requirements*.

Because the AMCA 205 standard and FEG metric are relatively new to the industry, they are summarized below.

Fan Efficiency Requirements

When Standard 90.1-2013 is published later this year, it will contain some new fan efficiency requirements.

6.5.3.1 Fan System Power and Efficiency.

6.5.3.1.3 Fan Efficiency. Fans shall have a Fan Efficiency Grade (FEG) of 67 or higher based on manufacturers' certified data, as defined by AMCA 205. The total efficiency of the fan at the design point of operation shall be within 15 percentage points of the maximum total efficiency of the fan.

Exceptions:

a. Single fans with a motor nameplate horsepower of 5 hp (4 kW) or less.

b. Multiple fans in series or parallel (e.g., fan arrays) that have a combined motor nameplate horsepower of 5 hp (4 kW) or less and are operated as the functional equivalent of a single fan.

c. Fans that are part of equipment listed under 6.4.1.1 Minimum Equipment Efficiencies – Listed Equipment – Standard Rating and Operating Conditions.

d. Fans included in equipment bearing a third-party-certified seal for air or energy performance of the equipment package.

e. Powered wall/roof ventilators (PRV).

f. Fans outside the scope of AMCA 205.

g. Fans that are intended to only operate during emergency conditions.

AMCA Standard 205

The scope of AMCA 205 is limited to fans having an impeller diameter of 5 in. (125 mm) or greater, operating with a shaft power 1 hp (750 W) and above, and having a total efficiency calculated in accordance with procedures specified in established fan test standards including:

• ANSI/AMCA 210 (ANSI/ASHRAE 51), *Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating;*

• ANSI/AMCA 230, *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification;*

• AMCA 260, *Laboratory Methods of Testing Induced Flow Fans for Rating*; and

• ISO 5801, *Industrial Fans—Performance Testing Using Standardized Airways*.

Fans that cannot be tested to one of these standards are excluded from AMCA 205 and any code or standard with fan efficiency requirements based on AMCA 205.

AMCA 205 defines FEG as "the efficiency grade of a fan without consideration of the drives" and as "an indicator of the fan's aerodynamic ability to convert shaft power, or impeller power in the case of a direct driven fan, to air power." The FEG is calculated using the fan's peak total efficiency, fan size, and application defined by its test configuration.

The FEG is an indicator of the fan's aerodynamic quality. It accounts for all the energy delivered to the airstream. As such, the fan total pressure is used in the determination of the FEG. For more information on fan peak total efficiency, see Reference 11.

FEG calculation procedures are provided in Annex A of AMCA 205. Generally, AMCA or fan manufacturers, not HVAC system designers, contractors, or code officials, use these calculations to establish the FEG. Once the FEG is determined, it is simply reported as fan data in manufacturers' brochures and electronic software to engineers, contractors, equipment packagers, etc., so they can establish compliance with the applicable code or standard. Manufacturers can elect

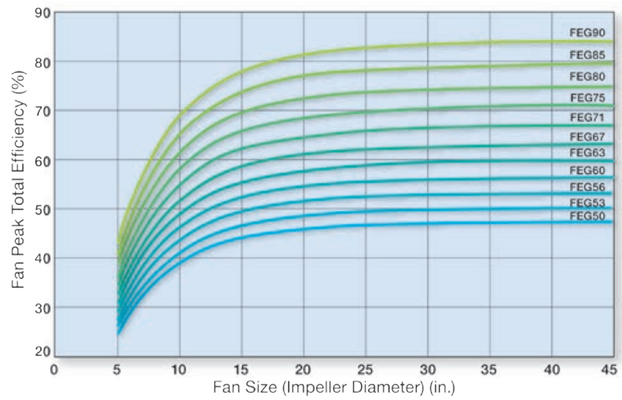

Figure 1: Fan efficiency grade curves for FEG50–FEG90. *Source*: AMCA 205-12 Energy Efficiency Classification for Fans.

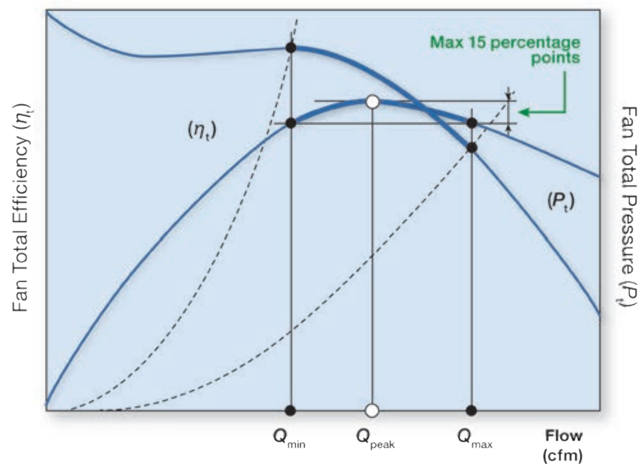

Figure 2: Allowable selection range based on operation within 15 percentage points of the peak total efficiency.

to have FEG ratings for fans certified by AMCA's Certified Ratings Program.

To streamline the application of AMCA 205, AMCA developed FEG curves with discrete bands based on fan size (impeller diameter) and fan peak total efficiency (*Figure 1*). The fan efficiency bands came about by collecting fan efficiency data on a variety of fan types and sizes from manufacturers around the world. The efficiencies were plotted and the bands were developed from the data.

The shape of the discrete bands helps accommodate an entire fan product line with the same FEG rating. As defined by AMCA 205, a fan belongs to a FEG if, for the fan impeller diameter, the fan peak efficiency falls between the upper and lower limits for that grade.

Not only is high peak efficiency important, so is selection of the fan to operate near peak efficiency. AMCA 205 states that the "fan operating efficiency at all intended operating point(s) shall not be less than 15 percentage points below the fan peak total efficiency" (*Figure 2*). AMCA encourages codes and standards bodies adopting AMCA 205 to include a selection window of this type in their fan efficiency requirement. Standard 90.1 has a selection window of 15 percentage points; the IgCC has a more restrictive 10 percentage points.

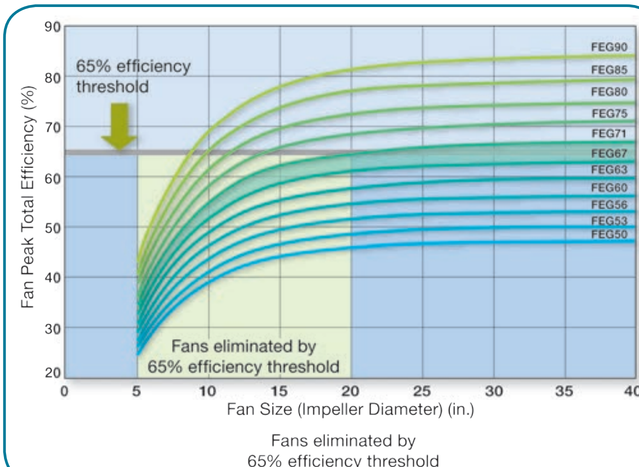

Figure 3: FEG curves in comparison with a straight-line single efficiency requirement. Regulating fans based on simple efficiency would eliminate many types based on fan size. For example, an efficiency based on 65% would eliminate many fans under 20 in. (508 mm) in diameter.

U.S. Fan Efficiency Codes and Standards

When fan efficiency requirements were first considered in 2007, the initial concept was to set a requirement at a single efficiency threshold, i.e., 65%. However, setting a simple efficiency threshold would eliminate many fans based on fan diameter (*Figure 3*). This is what drove the development of a fan efficiency classification system (i.e., FEGs) that could be used in codes and standards for energy and construction.

As mentioned previously, reducing fan energy consumption must go beyond the fan peak efficiency, hence, a complete fan efficiency requirement within a code or standard will have at least two clauses: one that establishes a baseline fan efficiency grade, and another that specifies a selection window relative to the fan's peak total efficiency.

As shown in the sidebar, the fan efficiency requirement in Standard 90.1-2013 has these two parts: one sets the efficiency requirement at FEG67 based on AMCA 205; the other requires the sizing/selection window to be within 15 percentage points of the peak fan total efficiency.

The 2012 International Green Construction Code, in a section that pertains only to buildings 25,000 ft^2 (2323 m^2) and less, being a "green" standard has more stringent requirements: a higher FEG level, FEG71, and a smaller selection window of 10 percentage points.

Beyond setting a FEG and selection window, codes and standards adopting AMCA 205 need to specify scope, such as

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fan sizes and applications. Fan efficiency regulations are new, and the industry must come to grips with understanding, applying, and enforcing a new class of requirements. Therefore, the Standard 90.1 requirement has a number of exceptions that will ease the burden of the standard while the industry climbs the learning curve. For example, the exceptions also take into account that regulating life/safety fans that operate only during emergencies would save little energy.

Among the Standard 90.1 exceptions is one for powered roof/wall ventilators. Standard 90.1 is the first widely adopted energy standard to include requirements for fan efficiency. Throughout the development of this new requirement, it was envisioned to use a single minimum energy efficiency metric for simplicity of implementation and enforcement. Consequently, some popular fan types and applications cannot presently meet the requirement without undue burden on designers and the fan industry in general. So certain fans, such as powered roof/wall ventilators, were exempted from the standard to allow fan manufacturers time to make design improvements or offer alternate solutions. AMCA International is working closely with Standard 90.1's committee, and others, to formulate more appropriate efficiency minimums that better serve powered ventilator applications, and to account for fans that currently fall outside the scope of AMCA 205.

Different codes and standards bodies are free to specify different FEG levels and sizing/selection windows, and develop their own list of exceptions.

Future Considerations

Current fan efficiency requirements and proposals specify a single FEG rating as a minimum efficiency threshold. While convenient for regulating fan efficiency for the first time, this may not be the best long-term solution, considering that energy efficiency requirements will likely become more stringent over time. *Figure 4* shows the peak total efficiency levels for centrifugal and mixed flow fans. As minimum FEG thresholds are increased, some fan types would no longer satisfy the requirement at a reasonable cost, thereby potentially disappearing from the market. One way to maintain a large selection of fan types would be to set different FEG thresholds for different types of fans. (EU) 327/2011 takes this approach.

Future developments for fan efficiency regulations include adoption of requirements based on AMCA 205 into other codes and standards. Proposals have been submitted to the 2015 International Energy Conservation Code and

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the 2014 IAPMO Green Supplement. Proposals are in the works for ANSI/ASHRAE/IES/USGBC Standard 189.1 and California Title 24.

Development of the U.S. Dept. of Energy's fan efficiency standard is just beginning; the Framework Document was published in the *Federal Register* on Feb. 1, 2013, which presents DOE's perspective of the fan market and the options it is considering for regulating commercial and industrial fans.[12] AMCA International is working with ACEEE, the Appliance Standards Awareness Project, and other organizations to jointly develop a proposal to DOE for the efficiency requirement and testing standards. Based on best-available information, a DOE requirement could be in place with enforcement between 2018 and 2020. To follow developments in fan efficiency codes, standards, and regulations, visit www.amca.org/feg.

Conclusion

The insertion of a fan efficiency requirement into ASHRAE Standard 90.1-2013 is significant because it will have HVAC designers, contractors, commissioning providers, code officials, and facility owners/operators thinking explicitly about fan efficiency grades and sizing/selection practice on a large scale. This scale is expected to grow as fan efficiency requirements make their way into the IECC, and ASHRAE Standard 189.1. The work done by ASHRAE's committees and subcommittees, and those of AMCA International, has helped set the stage for a DOE fan efficiency regulation.

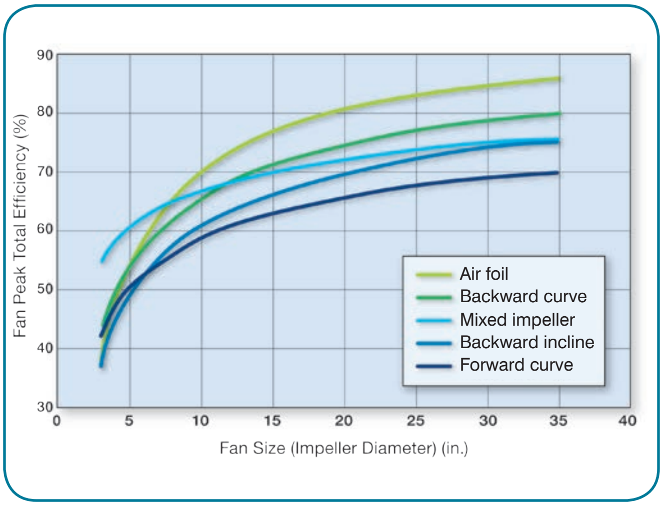

Figure 4: Fan efficiency curves based on fan type and size. Note the similarity of the curves to the FEG curves in *Figure 1*.

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