What You Need to Know

New Federal Regulations For Ceiling Fans

BY CHRISTIAN TABER, MEMBER ASHRAE, BEMP, HBDP; MICHAEL IVANOVICH, MEMBER ASHRAE

In January 2017, the U.S. Department of Energy (DOE) finalized its first efficiency performance standards for ceiling fans,[1] which included minimum efficiency requirements for large-diameter ceiling fans. The DOE is covering commercial and industrial fans and blowers in a separate rulemaking that has yet to be finalized.[2]

Ratings using the DOE test procedure allow comparisons of products based on electric input power and airflow. Fan companies that fail to use the prescribed DOE test procedure for making representations of ceiling fan performance would be subject to fines.[3] Because the DOE performance metric is not based on a specific airflow point, some additional effort on the part of the designer may be required to evaluate fan performance equitably at a specific airflow point.

Here, then, are four things to know about the DOE's regulation of ceiling fans that will help to ensure a successful and efficient ceiling fan selection.

1. The Test Methods Are Based on Well-Known Industry Standards

The DOE test methods for ceiling fans are defined in the Code of Federal Regulations (CFR).[4]

For small-diameter (7 ft [2.1 m] or less) ceiling fans, performance testing is based on a modified version of *ENERGY STAR® Testing Facility Guidance Manual: The Solid State Test Method for ENERGY STAR Qualified Ceiling Fans*,[5] which has been in use for testing residential ceiling fans since 2002. DOE's final rule incorporates some aspects from version 1.2 of the guidance manual, but is formally an update with respect to DOE's previous test procedure. Effective June 15, 2018, the DOE test method will be used for qualification for ENERGY STAR certification.

For large-diameter (greater than 7 ft [2.1 m]) ceiling fans, performance testing is based on a standard published by Air Movement and Control Association (AMCA) International: ANSI/AMCA Standard 230-15, *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification*. AMCA 230 initially was published in 1999;[6] the most recent revision, published in 2015,[7] was discussed in detail in a previous *ASHRAE Journal* article.[8]

As of July 2017, all temporary testing extensions granted by the DOE are expired; thus, all ceiling-fan manufacturers now are required to use the DOE testing methods as the basis of any published performance data, per DOE's representation requirements at 10 CFR 429.32.[3]

2. Fan Manufacturers' Performance Data Should Not Change Dramatically.

Although the DOE regulations differ slightly from AMCA 230-15, airflow is calculated according to AMCA 230-15, and published performance data should not vary dramatically from those obtained

Christian Taber is principal engineer, Codes and Standards, at Big Ass Solutions, manufacturer of HVLS fans. Michael Ivanovich is senior director, Industry Relations, at Air Movement and Control Association (AMCA) International, a not-for-profit manufacturers association.

Status of Draft Standards

At press time, AMCA 208 had been approved by AMCA and was undergoing ANSI accreditation. Publication was expected in January 2018. For more information about AMCA 208, see the peer-reviewed technical papers at www.amca.org/resources/knowledgebase.php.

ASHRAE Standard Project Committee 216 anticipated ASHRAE Standard 216P would be approved for its first public review in late 2017 or early 2018.

with AMCA 230-12. In the case of airflow calculated from thrust, it is worth noting the equation in AMCA 230-99 inflates performance by incorrectly multiplying by the square root of 2; if performance data are determined using AMCA 230-99, updated published airflow will decrease by approximately 30%. The erroneous airflow equation was removed for AMCA 230-07, and changes were made to the thrust equation to account for air density. A corrected version of the airflow equation was added in AMCA 230-12. *Table 1* shows how maximum-speed performance data for the same fan tested under each version of AMCA 230 would vary.

3. Minimum-Efficiency Standards Go Into Effect in 2020.

The implementation of these new test methods is the first step in creating minimum energy-efficiency requirements, also known as energy conservation standards.

Much like Integrated Part Load Value (IPLV) for chillers, the DOE efficiency metric (which is actually an efficacy metric) for ceiling fans is based on a weighted-average at multiple operating points, *i*. For large-diameter fans, the DOE calculates efficiency using a weighted average of data collected in standby mode and up to five speeds. The number of speeds to test is based on the number of available speeds, as specified in *Table 2* of the DOE test method. For calculating a ceiling fan's overall efficiency, the calculated efficiency at each tested speed will be equally apportioned active mode operating hours (e.g., if five speeds are tested, each speed is given 20% of the overall daily operating hours).[4] The resulting metric essentially is the airflow delivered by a fan in a "typical" day divided by the power consumed by the fan in a "typical" day.

Equation 1: DOE efficiency (efficacy) metric for large-diameter fans tested at five speeds

TABLE 1 Impact of test method on a circulator fan's maximum-speed performance data.

TEST METHOD	POWER (WATTS)	THRUST (POUNDS FORCE)	AIRFLOW (CFM)
AMCA 230-99	750	36.5	113,664
AMCA 230-07	750	37.0	N/A
AMCA 230-12	750	37.0	80,897
AMCA 230-15	750	37.0	80,365
DOE Regulations 2016/17	750	37.0	80,365

$$\text{DOE Efficiency (cfm/W)}=\frac{\sum_i \left(Airflow_i \times OH_i \right)}{W_{sb} \times OH_{sb} + \sum_i \left(W_i \times OH_i \right)}$$

$$\text{Large Diameter Fan DOE Efficiency} = \frac{Airflow_{20\%} \times Hours_{20\%} + Airflow_{40\%} \times Hours_{40\%} + \ldots + Airflow_{100\%} \times Hours_{100\%}}{W_{20\%} \times Hours_{20\%} + W_{40\%} \times Hours_{40\%} + \ldots + W_{100\%} \times Hours_{100\%} + W_{sb} \times Hours_{sb}}$$

where

$Airflow_i$ = Airflow at speed *i*
OH_i = Operating hours at speed *i*
W_i = Power consumption at speed *i*
OH_{sb} = Operating hours in standby mode
W_{sb} = Power consumption in standby mode

Starting in 2020, the DOE will require all ceiling fans to meet or exceed the specified DOE efficiency levels, which are set based on fan diameter and product class.[1]

4. Efficiency vs. Efficacy—Why the DOE Metric Does Not Tell You All You Need to Know.

Say you want to transport 100 people 100 miles (161 km). You could select a moped, which has a high fuel-efficacy rating at 100 mpg (42.5 km/L), or you could select a transit bus, which gets about 3 mpg (1.28 km/L). Because the moped can carry only one person, 100 mopeds would have to be used, and the mopeds would use approximately 100 gallons (379 L) of fuel. The bus could take everyone in one trip, using 33 gallons (125 L) of fuel. In this case, despite its lower efficacy rating, the bus would be the more energy-efficient choice.

The fan affinity laws make the same general principle hold true for ceiling-fan efficacy and efficiency. For a given diameter, slowing down a fan reduces input power and airflow, but input power is reduced more significantly than airflow. Consequently, at lower speeds, a fan would have a higher efficacy in terms of the DOE metric. This makes slowing a fan the simplest way to achieve a high efficacy at an equal or lower efficiency (*Figure 1*). Instead of relying solely on the DOE metric, a designer should determine the amount of airflow a fan needs to move or the size of the area that needs to be covered with elevated air speed and then compare fan-energy performance for fans that meet the needs of the application.

Fan 1 and Fan 2 are alike physically; however, Fan 2 has been programmed to operate at a 20% lower maximum speed. The DOE efficiency increases by 57 cfm/W (38%) solely because of the reduction in maximum airflow, while the fans' input power-to-output air power efficiencies at any common airflow point are identical.

FIGURE 1 Impact of reduced maximum airflow on DOE efficiency.

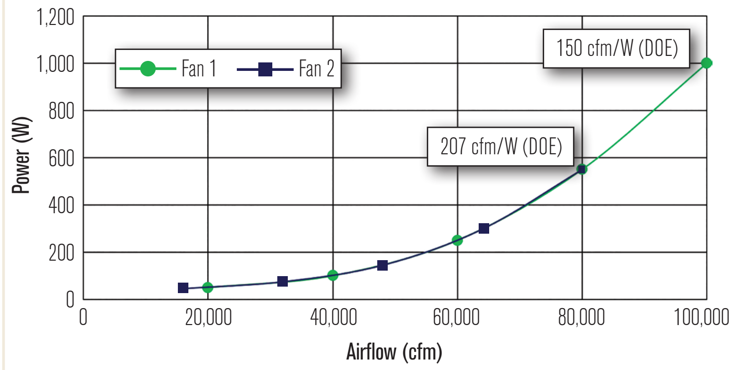


TABLE 2 Fan-efficiency metrics for three large-diameter ceiling fans.

	FAN 1		FAN 2		FAN 3	
FAN SPEED (PERCENT MAXIMUM SPEED)	AIRFLOW (CFM)	POWER (W)	AIRFLOW (CFM)	POWER (W)	AIRFLOW (CFM)	POWER (W)
100%	100,000	1000	80,000	550	80,000	733
80%	80,000	550	64,000	297	64,000	396
60%	60,000	250	48,000	144	48,000	192
40%	40,000	100	32,000	74	32,000	97
20%	20,000	50	16,000	45	16,000	59
Standby	–	10	–	10	–	10
DOE Efficiency	150		207		157	
FEI at Maximum Speed	1.31		1.43		1.07	
FEI at 80,000 cfm	1.43		1.43		1.07	

Beyond DOE Efficiency

Looking forward, two standards that may have a dramatic impact on ceiling fans are being developed: AMCA Standard 208-2017, *Calculation of the Fan Energy Index*,[9] and ASHRAE Standard 216P, *Methods of Test for Determining Application Data of Overhead Circulator Fans*.[10]

AMCA 208 is a calculation standard establishing a new metric: fan energy index (FEI), the ratio of the electric input power of a reference fan to the electric input power of a selected fan. In effect, FEI rates a circulator fan according to how much power is used to achieve a specified airflow rate and pressure. By accounting for the amount of work being done by a fan—and the utility provided to the user of the product—FEI potentially is more complete than the DOE metric because it removes the penalty imposed on high-efficiency fans that achieve relatively high airflow rates. At the same time, unlike the DOE metric, FEI penalizes low-airflow fans that do not create airflow efficiently.

For a specified airflow rate, FEI is calculated using Equations 2 and 3, which are simplifications of the equations provided in AMCA 208.

$$\text{FEI} = \frac{\text{Actual Fan System Efficiency}}{\text{Baseline Fan System Efficiency}}$$

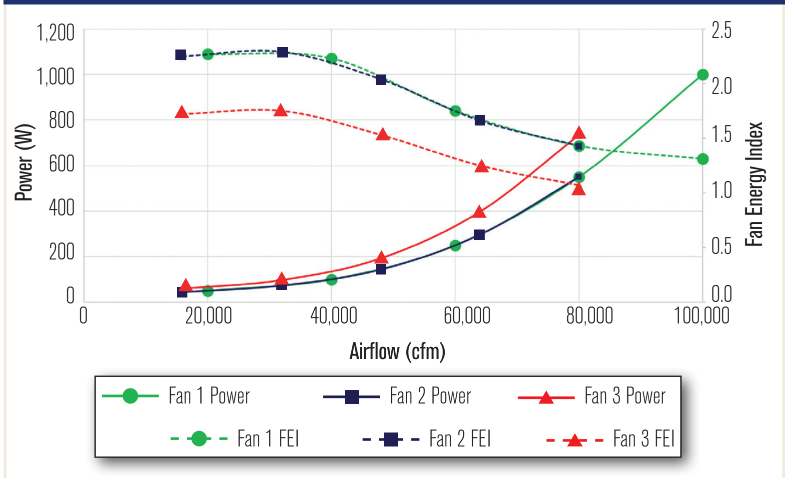
$$\text{FEI} = \frac{\text{Baseline Fan Electrical Input Power}}{\text{Actual Fan Electrical Input Power}}$$

Table 2 shows AMCA 230-15 performance data, DOE efficiency, and FEI for three fans. Fans 1 and 2 are from the previous example. Fan 3 is similar in design to Fan 1, but operates at the same lower maximum speed as Fan 2 and has a lower-efficiency motor. As a result, when compared to Fan 1, Fan 3 provides 20% less airflow at 100% of maximum speed and, for a given airflow, consumes approximately 33% more power. Because of the reduced maximum speed, the DOE efficiency of Fan 3 is greater than that of Fan 1. Because of the lower-efficiency motor and same operating speeds, the DOE efficiency of Fan 3 is less than that of Fan 2. On the other hand, the FEI for Fan 1 is significantly higher than that for Fan 3 and reflects the use of a better motor. Fans 1 and 2 have the same FEI at the same airflow because they essentially are the same fan. The impending publication of AMCA 208 may offer the DOE a better means of regulating ceiling fans and encourage increased efficiency at all airflow rates and diameters in future rulemaking.

Note that in *Table 2* the author proposes constants P_0, Q_0, and η_0 different than the ones in AMCA 208 for calculating the baseline fan electrical input power. The constants used to calculate the FEI values in *Table 2* were derived from the performance ratings of 170 large-diameter fans tested to AMCA 230-15. The constants in AMCA 208 were derived from data for fan types other than large-diameter ceiling fans.

Figure 2 shows airflow, power, and FEI at the five operating points required by AMCA 230-15 for all three fans. The power-vs.-airflow curve shows Fans 1 and 2 use less power at a given airflow than Fan 3, while the FEI values show Fans 1 and 2 have the same efficiency at a given airflow as and are more efficient than Fan 3.

FIGURE 2 Fan performance data for Fan 1, Fan 2 and Fan 3 from *Table 2*.



ASHRAE Standard 216P, *Methods of Test for Determining Application Data of Overhead Circulator Fans,* will provide a standard test method for measuring the occupant-level air speed of overhead circulation fans. The data collected using Standard 216P will complement power and airflow data from AMCA 230-15. Occupant-level air speed will be used to demonstrate compliance with the thermal-comfort requirements of ANSI/ASHRAE Standard 55-2017, *Thermal Environmental Conditions for Human Occupancy*,[11] and enable designers to optimize low-energy designs that use the cooling effect of air movement to maintain comfort.

Summary

Federally mandated test methods for small- and large-diameter ceiling fans are now in place. The small-diameter test method is based on the well-known *ENERGY STAR Testing Facility Guidance Manual: The Solid State Test Method for ENERGY STAR Qualified Ceiling Fans*, with modifications, while the large-diameter test method is based on the 2015 version of AMCA 230.

Although the DOE regulations vary slightly from the 2015 version of AMCA 230, published performance data determined using the DOE test procedure should not differ dramatically from those determined using the 2012 version of AMCA 230. However, there will be significant differences compared with fan-rating data calculated using the 1999 version of AMCA 230. The DOE regulations require that manufacturers with published ratings for ceiling fan performance that are not consistent with the DOE test method be re-tested to the DOE test method to make public representations of ceiling fan performance. Compliance with the DOE energy conservation standards for ceiling fans will become mandatory in 2020.

Designers should be aware that the DOE metric for large-diameter fans aggregates performance at the maximum and part-load airflow settings inherent to the fan. For comparing performance of fans at a given airflow point, designers may have to look beyond the DOE metric. Soon, in addition to data determined using the DOE test method, engineers will be able to use AMCA 208 to determine FEI and have applications data from ASHRAE Standard 216P testing to guide ceiling-fan selection and application.

References

1. DOE. 2017. “Energy conservation program: energy conservation standards for ceiling fans: Final Rule.” *Federal Register* 82:6826. U.S. Department of Energy. https://www.federalregister.gov/documents/2017/01/19.
2. DOE. 2017. “Commercial and Industrial Fans and Blowers.” U.S. Department of Energy. https://www1.eere.energy.gov/buildings/appliance_standards/standards.aspx?productid=51&action=viewlive.
3. DOE. 2016. “Civil Penalties for Energy Conservation Standards Program Violations—Policy Statement.” https://energy.gov/gc/downloads/civil-penalties-energy-conservation-standards-program-violations-policy-statement.
4. Office of Federal Register. 2017. “Uniform Test Method for Measuring the Energy Consumption of Ceiling Fans, 10 CFR Appendix U to Subpart B of Part 430.”
5. EPA. 2002. “ENERGY STAR® Testing Facility Guidance Manual: Building a Testing Facility and Performing the Solid State Test Method for ENERGY STAR Qualified Ceiling Fans, Version 1.1.” U.S. Environmental Protection Agency.
6. ANSI/AMCA Standard 230-99, *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification*.
7. ANSI/AMCA Standard 230-15, *Laboratory Methods of Testing Air Circulating Fans for Rating and Certification*.
8. Taber, C. 2015. “Circulator fan performance testing standards: The thrust of ANSI/AMCA Standard 230-15.” *ASHRAE Journal* 57(9).
9. AMCA Standard 208-2017, *Calculation of the Fan Energy Index*.
10. ASHRAE Standard 216P, *Methods of Test for Determining Application Data of Overhead Circulator Fans*.
11. ANSI/ASHRAE Standard 55-2017, *Thermal Environmental Conditions for Human Occupancy*. ■