PRODUCT APPLICATION

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

HVLS – High Volume Low Speed Fans

What is an HVLS fan?

The high volume low speed (HVLS) fan is a relatively new concept in the heating, ventilation, and air conditioning (HVAC) industry. The original HVLS fan was developed in the late 1990s for use in agricultural applications to keep dairy cows more comfortable and productive. Uses for the fan have grown and now offer circulation options in many commercial and industrial settings.

HVLS fans are large-diameter, ceiling-mounted axial fans designed to circulate considerable volumes of air at low operational speeds. The number of blades used varies by design and manufacturers, but more manufacturers today use between three and eight blades. A common assumption among those unfamiliar with HVLS fans is that more blades create more air movement. Therefore, if three blades do a good job moving air, then six blades should work twice as well. However, testing demonstrates little difference in performance between a three and six-bladed fan when motor power is held constant (Table 1).

	3- Blade Fan	6-Blade Fan
Motor Power	500 W	500 W
Max RPM	86	69
Max CFM	124,500	128,100

Table 1

Blade count alone does not indicate better HVLS design or higher performance. Factors such as output power and the torque of the motor, the operating speed of the fan, and the aerodynamic design of the airfoil blades have a significant influence on performance. As such, making a selection solely on the number of blades to achieve a perceived level of performance often leads to undesirable results.

The motor technology used also affects HVLS design and performance. Two distinctly different types of motors in use today are gearbox motors and direct drive motors. Gearbox motors utilize common, high RPM motor designs coupled with a gear system to reduce speed and increase torque output. Direct drive motors are designed specifically for lower operating speeds and generating high and continuous torque without the need for gears.

While both motor types deliver the required power and torque for HVLS fan performance, the two technologies produce noticeable differences in efficiency, reliability, and sound. Gearboxes have been the industry standard for HVLS fans, but the technology is outdated for this application and has several limitations. In particular, gearbox motors have many moving pieces including gears and bearings that require routine maintenance to ensure proper operation. These parts also introduce inefficiencies causing higher operating costs and increased downtime.

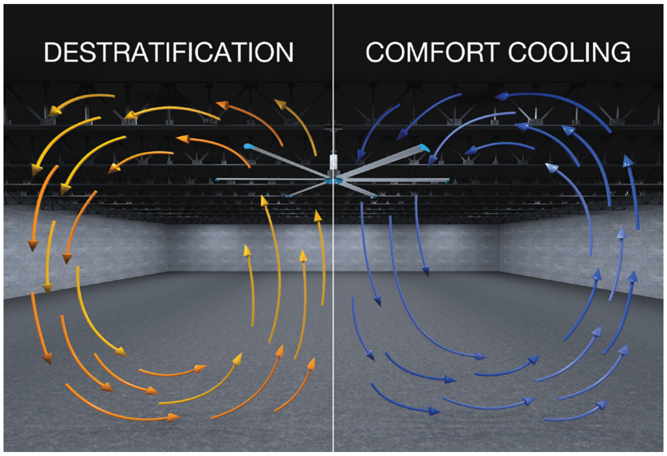
Gearbox technology also contributes to louder operating sound and continuous noise in a facility that may be objectionable to building occupants. Despite these concerns, many HVLS fans manufactured today still use gearbox technology. The direct drive motor, however, has gained industry favor because of many benefits it offers including quieter operation, minimal maintenance, and overall energy savings since it has no gears and fewer mechanical parts. As a result, settings where noise affects productivity and occupant comfort, such as commercial and institutional buildings, likely would opt for the quieter direct drive. Still, even noisy settings including factories and warehouses benefit from the efficiency and other features (i.e., reduced maintenance) that direct drive motors offer.

Why use HVLS fans?

The primary reason HVLS fans continue to gain in popularity is the ability to provide thermal comfort in commercial and industrial buildings. This ability to keep people comfortable relates to a standard of the American Society of Heating, Refrigeration, and Air-Conditioning Engineers (ASHRAE) known as ASHRAE 55. This standard addresses the thermal comfort that people feel in building environments. ASHRAE Standard 55 combines indoor thermal environmental factors and personal factors to produce conditions acceptable to a majority of occupants in the space. Environmental factors addressed in this standard are temperature, humidity, and airspeed along with personal factors such as activity level (metabolic rate) and the type of clothing worn. Studies show that thermally comfortable people are more productive, and that well-designed HVAC systems including HVLS fans aid in the increase of thermal comfort, which correlates to overall productivity increases.

HVLS fans have many uses that contribute to thermal comfort including destratification, comfort cooling, and the mitigation of condensation in a building to increase safety. Destratification is the reverse movement of the fan to blend thermal layers in the affected space, which results in a uniform temperature throughout.

Comfort cooling is the forward movement of the blades to create circulation and an evaporative cooling effect for the occupants within a space. Both destratification and comfort cooling offer significant benefits to any application and save building owners substantial costs by reducing the need for running other HVAC equipment.



Maintaining acceptable thermal environmental conditions makes buildings more comfortable for occupants. However, another aspect of acceptable thermal environmental conditions is the impact those conditions have on a building structure. For example, when warm, humid air interacts with much cooler floors, it causes condensation to form on the surface, commonly known as “sweating slab” syndrome. This increases the risk of slips, trips, and falls resulting in injury and workers’ compensation claims. The National Safety Council reports the average works compensation claim in 2020-21 for slips and falls was $49,971 (https://injuryfacts.nsc.org/work/costs/workers-compensation-costs). Airflow from an HVLS fan maintains dry conditions even in warm, humid climates by increasing evaporation of condensation on surfaces. This eliminates the moisture and the potential risk associated with it. Another example is maintaining product viability in the same warm, humid conditions. These conditions can affect packaging aesthetics and even product integrity. A company could purchase between seven and ten HVLS fans for the cost of an average workers’ compensation claim, making HVLS fans a wise investment for employee safety and comfort.

Small circulator fans are often substituted in certain comfort cooling applications to save on upfront building costs. The purchase price of numerous circulators can be much less than that of an HVLS fan, implying coverage using multiple circulators could match that of an HVLS fan. However, using these fans in a large space exposes several deficiencies. The coverage area for conventional circulators is much smaller, resulting in the need for many more fans to cover the space effectively. Even with a number of conventional fans, the coverage in the space is not uniform, providing more air movement in one area and less in another. The smaller conventional fans also create more turbulence which is a result of needing higher fan speed to move the same volume of air. One HVLS fan can cover a space up to 23,000 square feet (or half of a football field), providing even and gentle air movement throughout the space.

Finally, aesthetics is a growing consideration for selecting HVLS fans. The HVLS fan not only achieves the desired thermal conditions, many architects now incorporate the aesthetic appeal of these fans as part of the overall building design. Architects cite reasons of configurability, custom paint options, and the bold large design for their decision. HVLS fans provide numerous benefits to many different applications, all while doing it in style.

U.S. Department of Energy Regulation

The U.S. Department of Energy (DOE) sets the energy and water conservation standards for mechanical, electrical, and plumbing equipment. The DOE standards for large-diameter ceiling fans (fans larger than 84.5 inches in diameter) can be found in section 10 CFR 430.32(s)(2)(ii) of the Energy Conservation Standards. As of January 21, 2020, failure to comply with the latest DOE standards can result in major fines and product recalls for the manufacturer not in compliance. HVLS products can only be approved if the fan performance is first certified by a third party such as the Air Movement and Control Association International Inc. (AMCA) and meets the following Ceiling Fan Energy Index (cFEI) requirements:

- 1.00 at 100% of operating speed
- 1.31 at 40% operating speed or the nearest speed that is not less than 40% speed.

The Ceiling Fan Energy Index (cFEI) is defined as the ratio of the *referenced* fan's electrical power to the *actual* fan's electrical input power at the same duty point. The calculation and ceiling fan constants for the referenced fan electrical power (FEP_ref) can be found in Table 5.1 of AMCA 230-23 and the actual fan electrical input power (FEP_act) can be measured and determined in accordance with the standards also in AMCA 230-23. More simply put, the FEP_act is the measured input power into the ceiling fan before the motor and before the controller.

HVLS fans are tested, rated, and cataloged based on the methods spelled out in AMCA 230-23 for large-diameter circulator fans. Testing for large-diameter ceiling fans includes operating the fan through its entire operating range and collecting thrust information with a torque cell which can be converted back into airflow (CFM). The following graph compares actual fan airflow (CFM) to manufacturers' published airflow. In this example, manufacturers 2 and 3 would be in violation of the DOE fan performance regulations for publishing invalid airflow performance data.

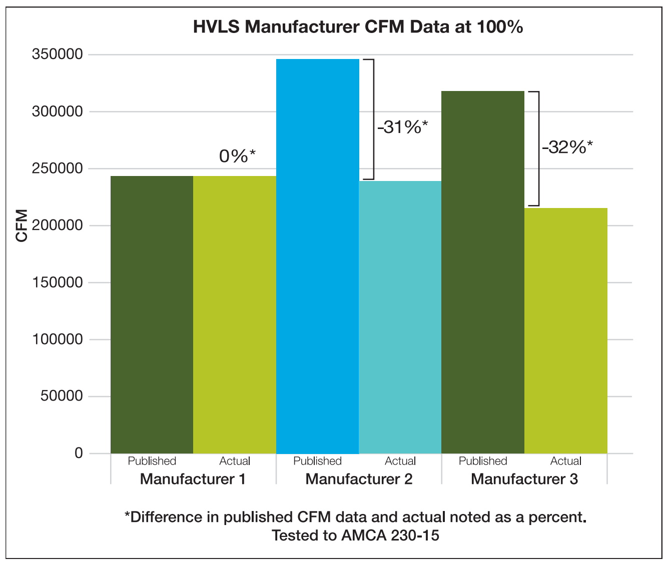
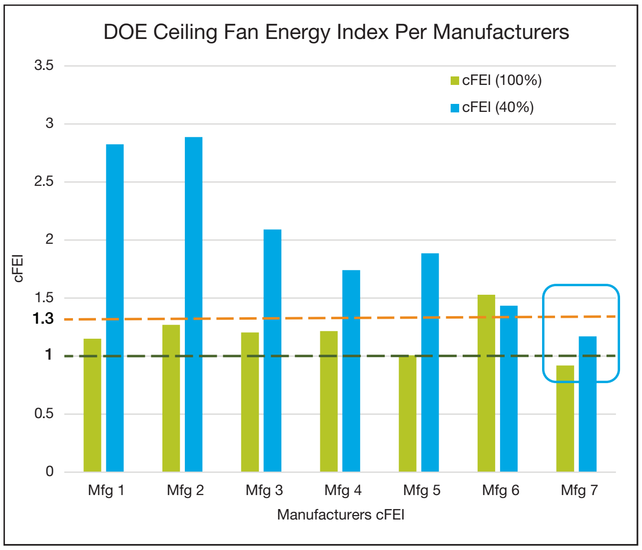


Figure 1

The cFEI regulations set in place today are a good first step to lowering energy loads of HVAC equipment. However, it is expected that the DOE will continue to increase its cFEI requirements in the coming years. Selecting a fan that exceeds the DOE requirements today is critical to ensure the unit will be in compliance on the day of commissioning. The chart below compares manufacturers' published cFEI data on a 24-foot HVLS fan. In this example, all manufacturers except for "Mfg 7" produce a fan in compliance with the DOE cFEI regulations.



A list of all certified products can be found on the AMCA website (https://www.amca.org/certify/product-search/license-type/circulating-fan.html). Simply making a selection from one of these suppliers guarantees that the product complies with the DOE regulations, therefore the specifying engineer will not need to run through the energy calculations on their own.

Selection Consideration and Conclusion

HVLS fans offer many safety, productivity, and efficiency benefits for the building owner in large space applications including multifamily residential, commercial, and industrial. Design professionals must ask two key questions to specify HVLS fans accurately: Is the manufacturer's performance data certified by an independent third party (AMCA)? And does the fan meet DOE minimum efficiency?

Design professionals should also consider fan placement, which is critical for maximum performance and occupant safety. Installed fans must use the manufacturer's recommended clearances around the fan for safety and reliable system design, including minimum distances between the fan and the ceiling, floor, walls, HVAC discharges or intakes, additional HVLS fans, and small obstructions like plumbing or ductwork. The ceiling structure must also support the hanging weight of the fan and operational torque for safe operation. Fans utilizing gearbox motors that require regular maintenance must be easily accessible from the floor below. Designers should avoid placing HVLS fans directly beneath light sources to prevent a strobing effect that fan rotation may cause.

Summary

Selecting an HVLS fan for use alone or as part of an HVAC system offers the building owner many safety, productivity, and efficiency benefits. HVLS fan design, application, and selection should be based upon independent third-party tested and certified performance.

Verify performance data using recognized standards from independent third parties. Choose direct drive motors over the gearbox power source. Direct drive HVLS fans have proven value in providing energy efficiency and eliminating sound, repairs, maintenance, and reliability issues that plague fans with gearboxes. Building owners will enjoy the architectural and air circulation improvements in their space when these recommendations for selecting HVLS fans are followed.

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