HVLS Ceiling Fans: Untangling Ratings and Finding DOE-Compliant Products

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Course Description

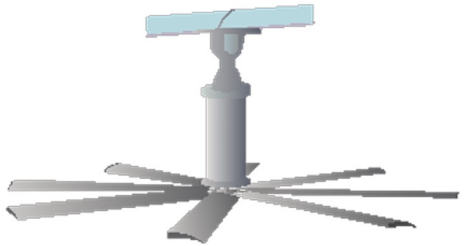
High-volume, low-speed (HVLS) ceiling fans are used to destratify indoor spaces, mitigate heat stress, and provide improved occupant comfort. But how can you be certain that the product selected will perform as marketed? This session will cover the basics of HVLS fans and take a deep dive into the steps needed to ensure you select the best HVLS fan for your project.

Outline

- HVLS Fan Overview
- Determining Fan Performance
- DOE Regulations
- Additional Codes & Standards
- Fan Selections
- Example Specifications

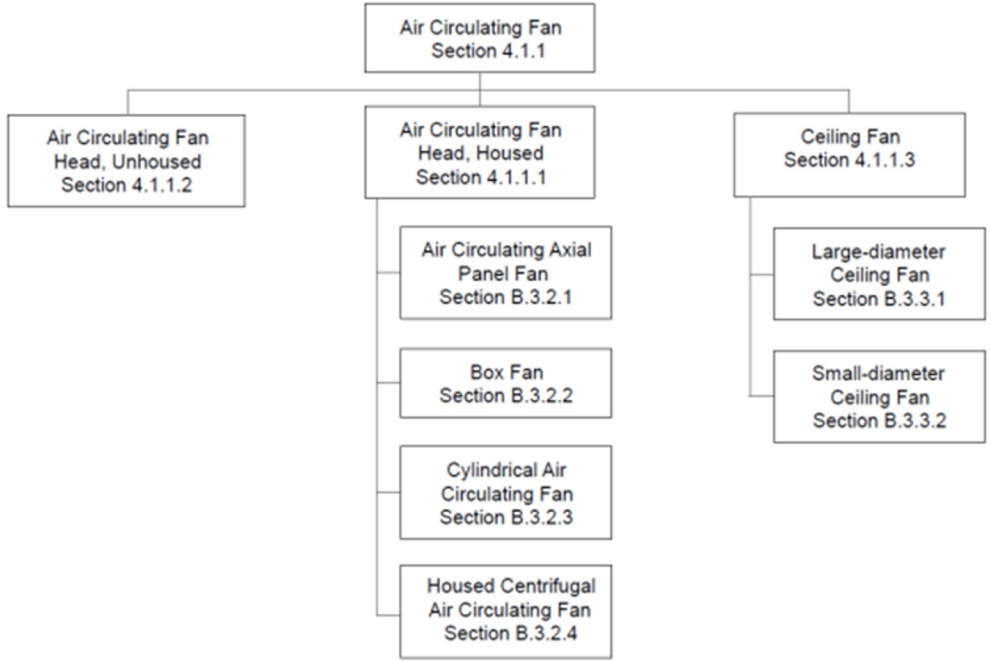
HVLS Fan Overview

ANSI/AMCA 230-23 - Appendix B



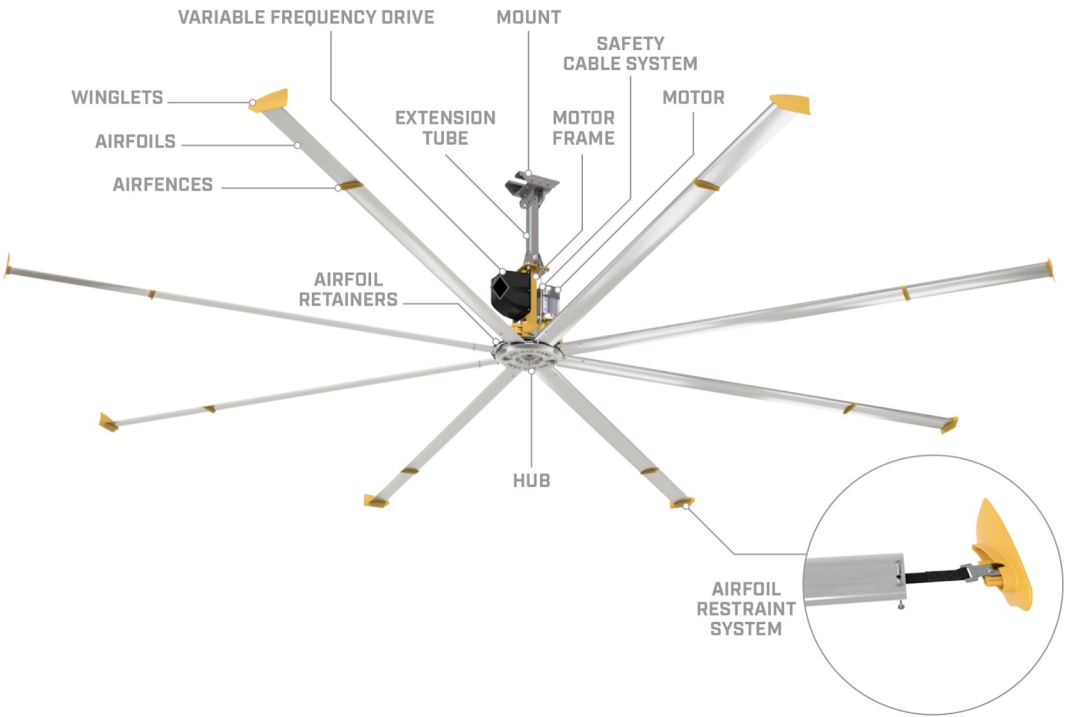
B.3 Air circulating fan subcategories

The primary categories of air circulating fans may be divided into subcategories based on various characteristics of the fans within the scope of this standard. The subcategories, if applicable, are defined in this section and summarized in Figure B.1. A partial list of common marketing names for each fan category or subcategory is also provided at the end of each definition in sections B.3.1 to B.3.3.

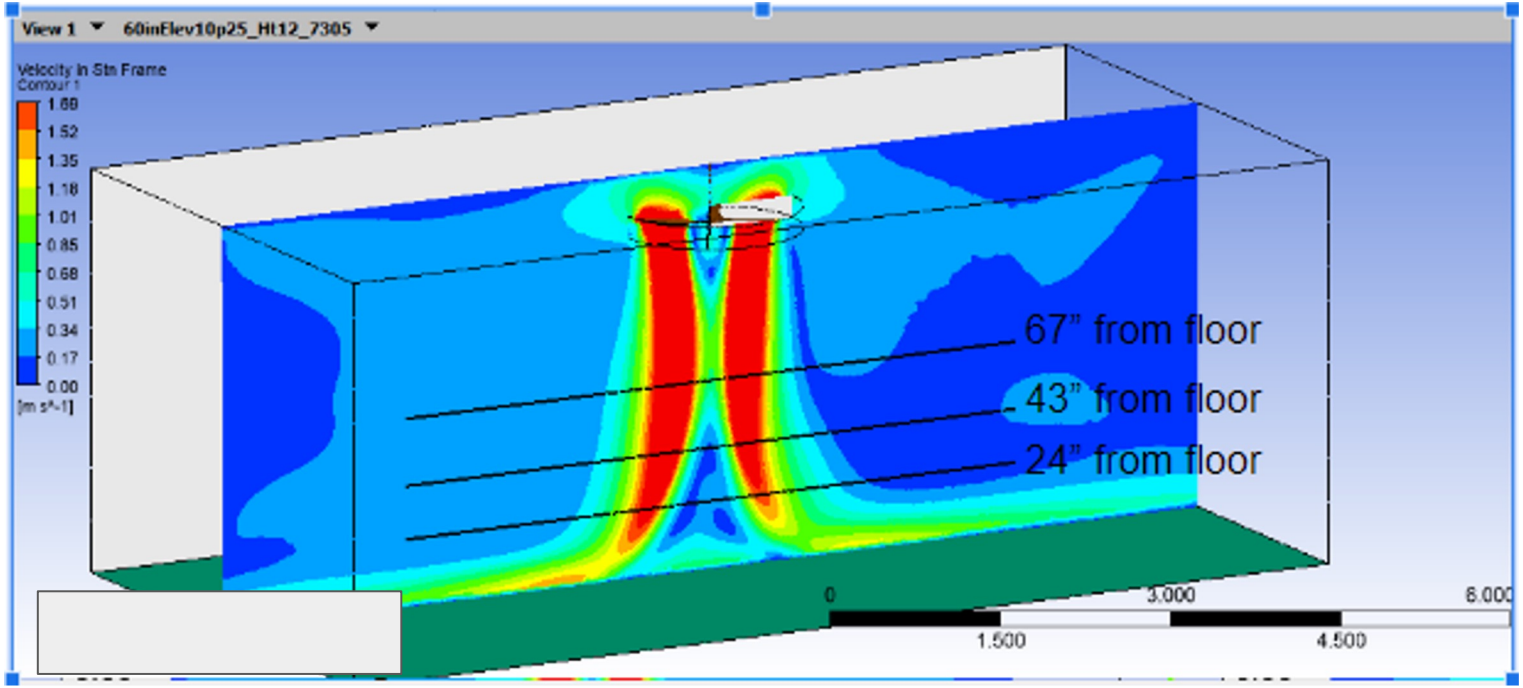


What is an HVLS Fan?

- No legal/formal definition for High Volume Low Speed
- Air circulating fan
  - Ceiling fan
- Large >7’ Diameter
- Low RPM - 24’ Fan ~60 RPM
- Low HP - ≤2.5 hp motor
- 2 to 8 blades
- Tip speeds 1,100-5,500 fpm
- Common acronyms - HVLS, LDCF, HVLV, LSHV, LVLS, etc.



What Does an HVLS Fan Do?



Relative Efficiency - Airflow Vs Power (Side Note)

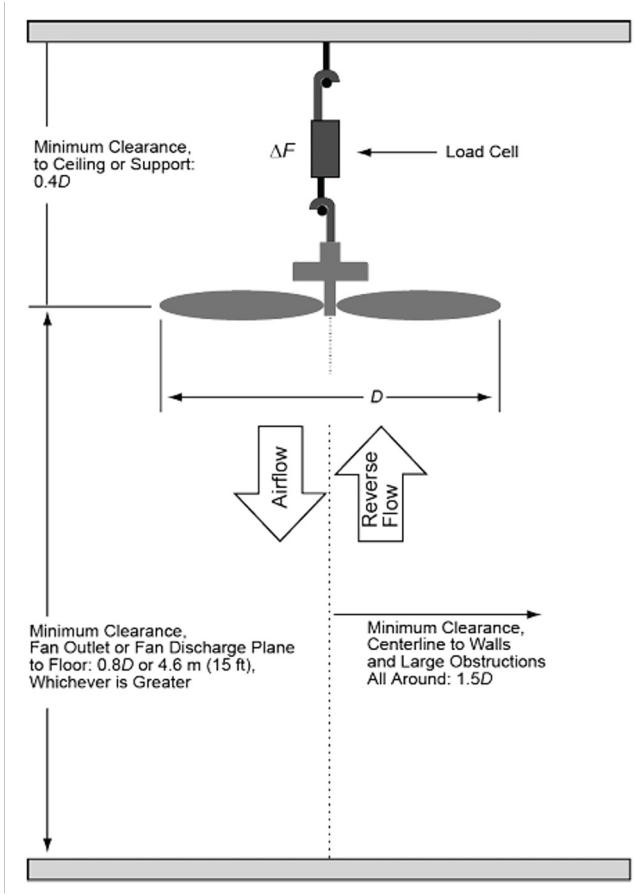
Fan Type	Approximate Efficacy (CFM / W)
HVLS Fan 6.1m (20ft) @100%	143
HVLS Fan 6.1m (20ft) @20% RPM)	344
HVLS Fan 3.7m (12ft) @100%	101
HVLS Fan 3.7m (12ft) @ 20%	297
Ceiling fan with AC motor - 52”	75
Axial panel - 36”	26
Upblast roof exhaust fan - 42” (0” s.p.)	22
Cylindrical air circulating fan - small thermal destratifciation - 12”	16
Box fan - 31”	15
Unhoused air circulating fan head - 24”	13
Cylindrical air circulating fan - barrel/tube - 24”	12
Rooftop HVAC supply fan (5 ton)	3

1 CFM ~ 0.03 CMM

Determining Fan Performance

AMCA 230 - 2015 & 2023

- Measure (2-5 Speeds)
  - Load differential
  - Power
  - Speed
- Calculate
  - Thrust (std air)
  - Airflow
  - Power (std air)
  - Ceiling Fan Energy Index CFEI



Ceiling Fan Efficiency - Wire-to-Air

Wire

To

Air

Input Power

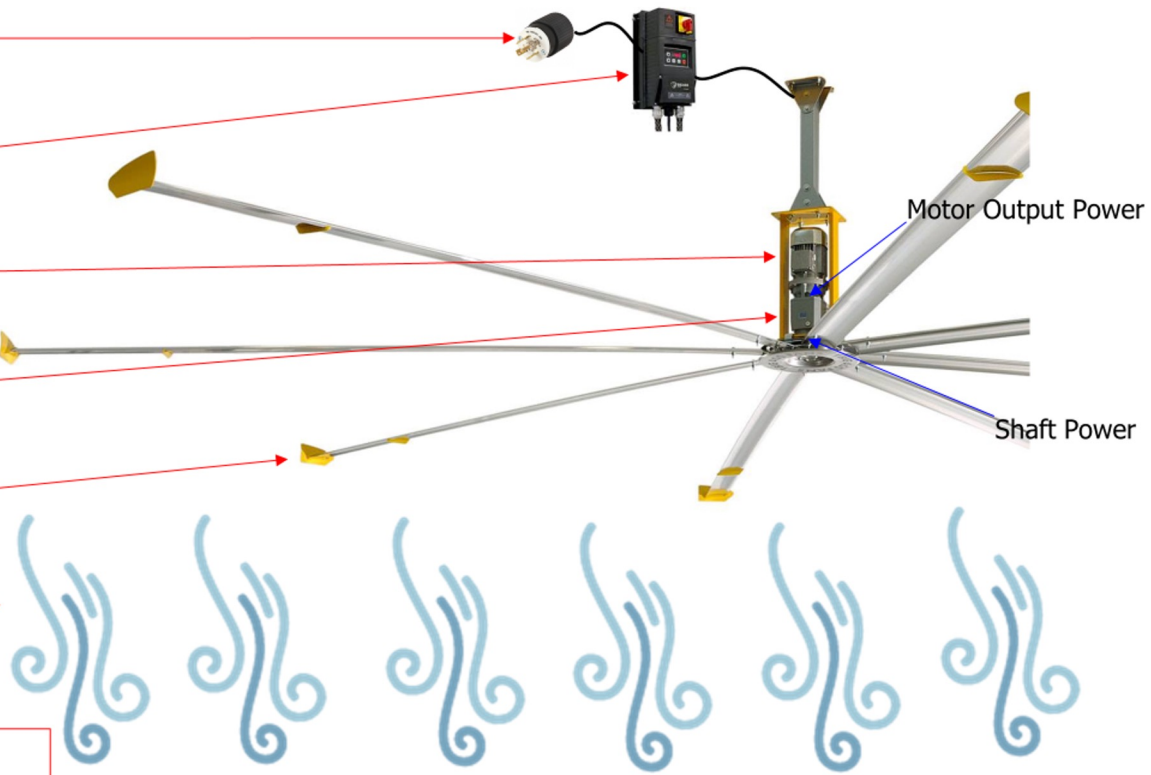
Drive Efficiency

Motor Efficiency

Gearbox Efficiency

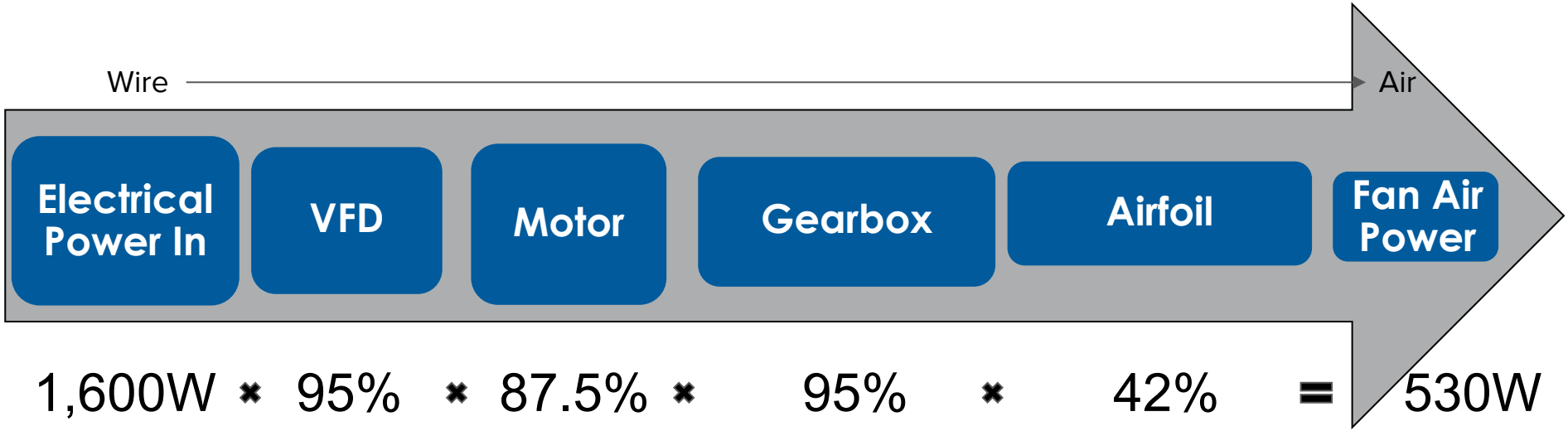
Airfoil Efficiency

Output Air Power



Overall Efficiency =
Output Air Power / Input Electric Power

Wire-To-Air Fan Efficiency Calculation



1,600W × 95% × 87.5% × 95% × 42% = 530W

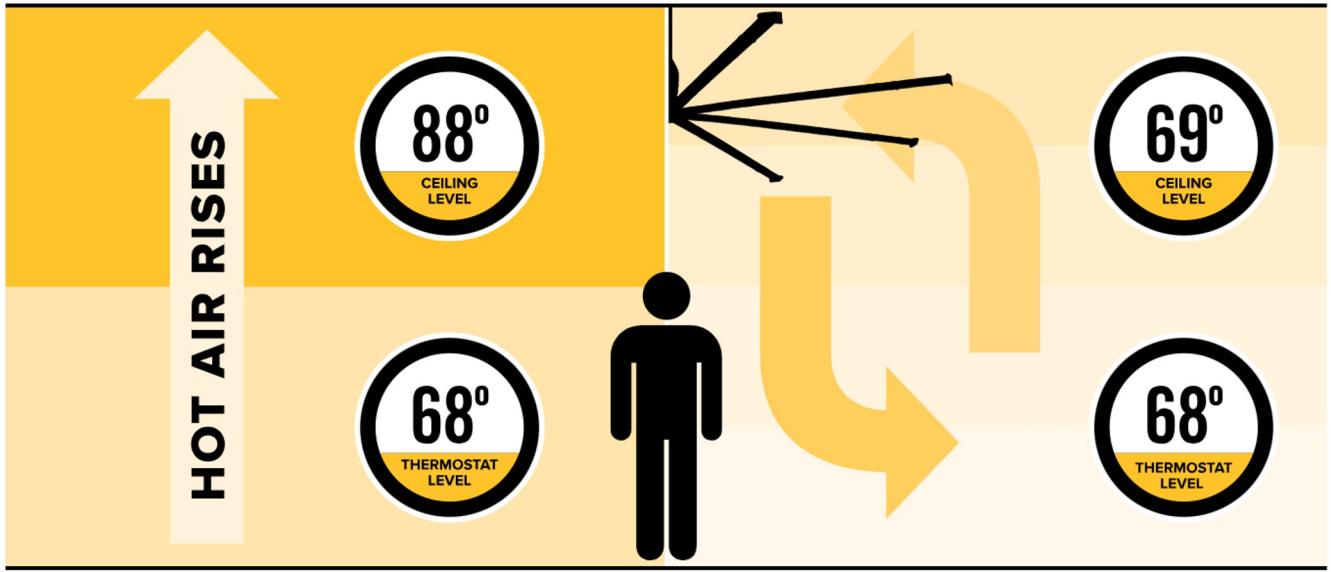
530W of Air Power = 245,000 cfm for a 24’ fan

530W / 1600W = 33% Efficient

$CFEI_{100} = 1.31$

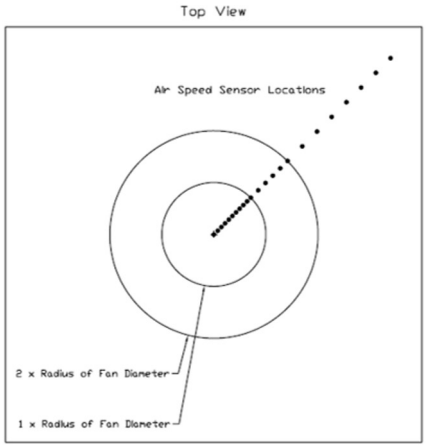
Standard 230/208 - Ceiling Fan Selections Key Criteria

1. Airflow
2. Power
3. Speed
4. Efficiency (CFEI)



Standard 216: Overview

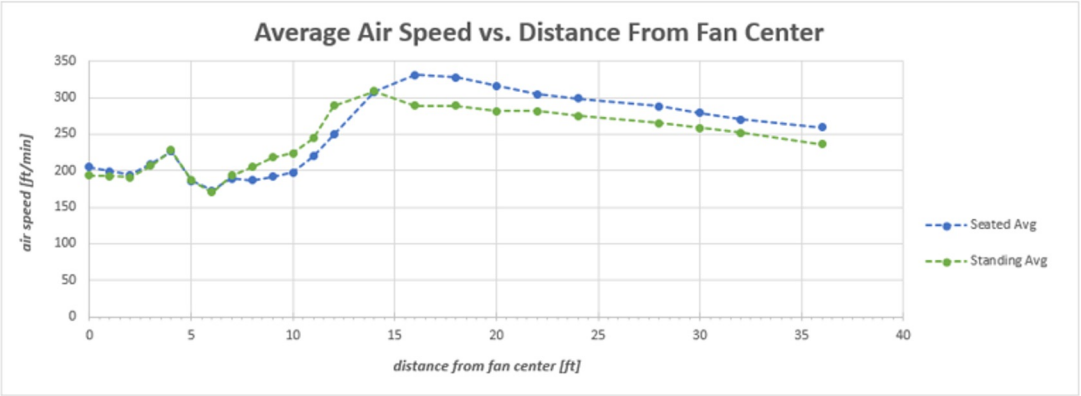
- Fan mounted in test chamber
  - Small - 20’x20’x11’ (6.1x6.1x3.4m)
  - Medium - 50’x50’x22’ ±1.5 (15.2x15.2x6.7m)
  - Large - 80’x80’x32’ (24.4x24.4x9.8m)
- Air speeds measured at four test points per test position
  - 4”, 24”, 43”, and 67” AFF (0.1, 0.6, 1.1, 1.7m)
- Test positions – center to corner of room
- Power measured per 10 CFR 430
- Air speed + power measurements → Application data & metrics



Where to find out more - [Preview ASHRAE Standards (Free)]

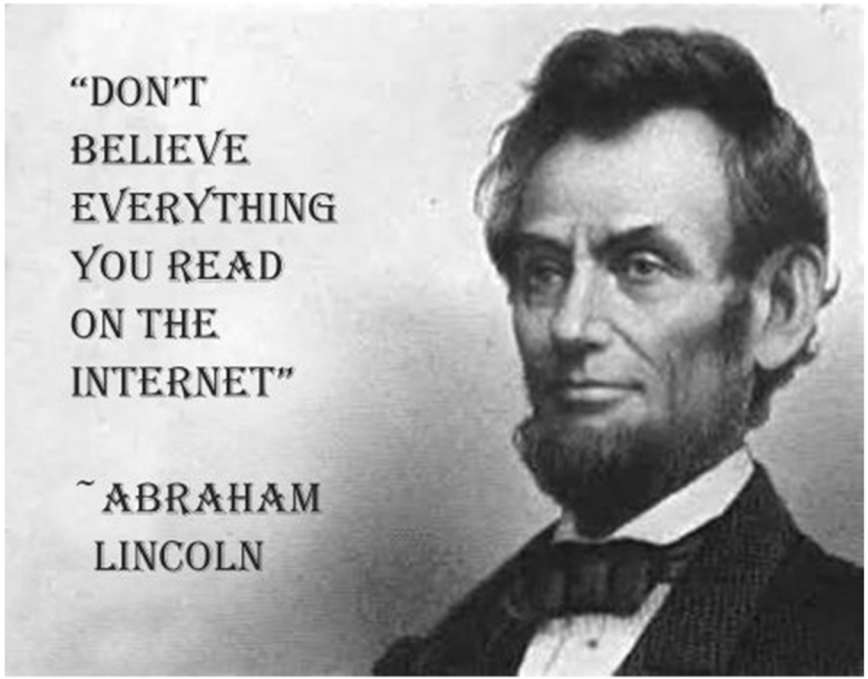
Standard 216 Based Ceiling Fan Selections Key Criteria

- 8.4 - Average Air Speed – Combined to create average air speed profile
- 8.5 - Maximum Average Air Speed – Too Cold (PMV<-0.5), Paper flutter
- 8.6 - Minimum Average Air Speed – Too Hot (PMV>0.5)
- 8.7 – Uniformity - Spot cooling or numerous occupants
- 8.9 - Room Average Cooling Effect – Estimated thermostat increase
- 8.11 - Cooling Coverage Fraction – High-speed test, does it cover the space
- 8.12 - Heating Draft Risk Fraction – Optional low-speed test, will it draft?



DOE Regulations & Reliable Data

Critical Thinking



Ceiling Fan Regulations

Office of
ENERGY EFFICIENCY & RENEWABLE ENERGY

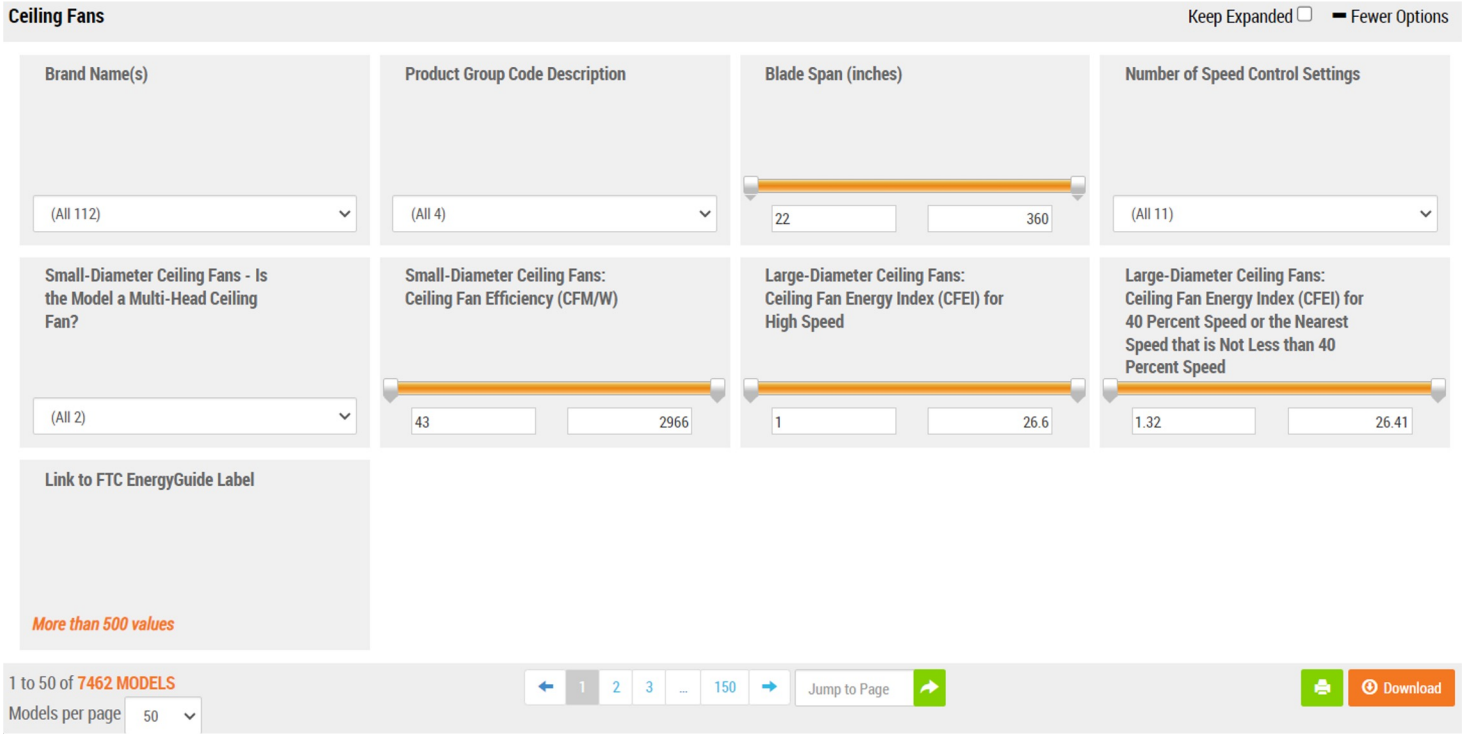
- 10 CFR Part 430, Appendix U to Subpart B
  - Product classes
  - Test procedures (AMCA 230 for LDCF)
  - Efficiency metric
  - Performance representations (CFM, W)
  - Effective 1/23/17, Updated 9/15/22
- 10 CFR 430.32 Energy and water conservation standards and their compliance dates
  - Minimum efficiency by product class
  - Effective 1/21/2020 (modified 12/27/2020)
  - Added to next revision of ASHRAE 90.1 and IECC
- 10 CFR Part 429 - Certification, compliance and enforcement
  - Requirements for submission of products to US DOE CCMS database

DOE Compliant Large Diameter Ceiling Fans

- Basic LDCF Requirements
  - Test to DOE test procedure (AMCA 230-15)
  - Exceed DOE minimum efficiency levels
  - Submit compliance data with testing and efficiency to DOE
- Significant fines for non-compliance

Where to find out more - US DOE Compliance Certification Database
Where to find out more - AMCA LDCF Website

US DOE Compliance Certification Management System (CCMS) - Compliance Certification Database (CCD)

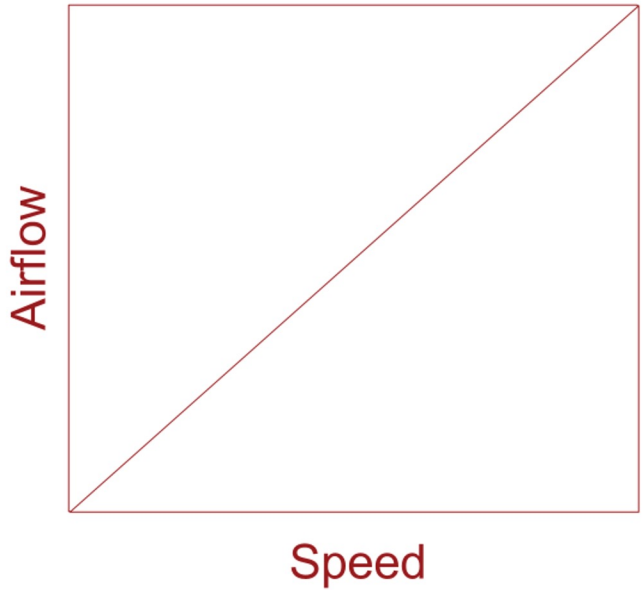


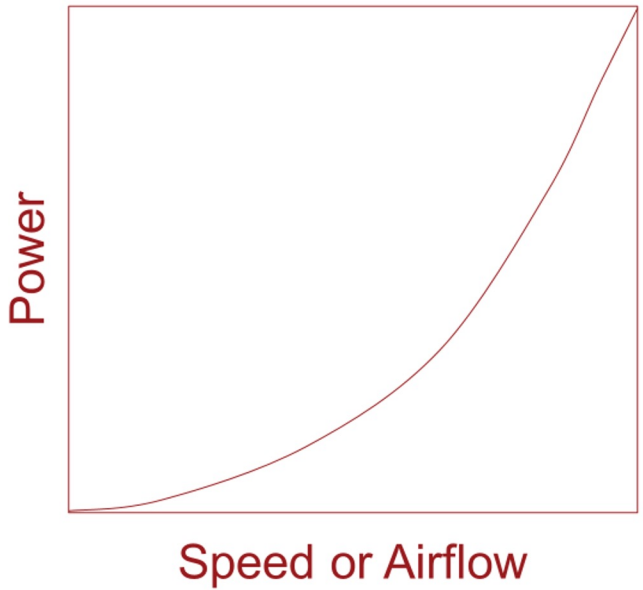
https://www.regulations.doe.gov/certification-data/CCMS-4-Ceiling_Fans.html#q=Product_Group_s%3A%22Ceiling%20Fans%22

Rule of Thumb (RoT) Performance

Diameter	Input Power	Drive / Motor / Blade Efficiency	Airflow
7.3m (24ft)	1.5kW	92.2% / 86.8% / 42%	6456 cmm (228k cfm)
6.1m (20ft)	1.5kW	92.2% / 86.8% / 42%	5069 cmm (179k cfm)
4.9m (16ft)	1.1kW	91.3% / 85.2% / 42%	3299 cmm (117k cfm)
3.7m (12ft)	1.1kW	91.3% / 85.2% / 42%	2209 cmm (78k cfm)

Calculations based on equations from AMCA 214 & 230, $CFEI_{100}$ = 1.10





$$\frac{\text{Airflow}_1}{\text{Airflow}_2} = \frac{\text{Speed}_1}{\text{Speed}_2}$$

$$\frac{\text{Airflow}_1}{\text{Airflow}_2} = \left(\frac{\text{Speed}_1}{\text{Speed}_2}\right)^3$$

Airflow and Speed = Linear

Power and Speed = Nonlinear

AMCA Certified Large Diameter Ceiling Fans

- Performance Data
  - Airflow - 5 Speeds - 20% to 100%
  - Power - 5 Speeds - 20% to 100% + Standby
  - NO sound

Where to find out more - [AMCA Certified Product Search]

Additional Codes & Standards

Fan Safety - UL 507 & CSA Standard 22.2 No. 113

- Third party safety standard for fans
- Provides a minimum safety level, but does not cover industrial impact testing
- Requires blades have smooth/rounded leading edges, safe electrical systems, etc.
- Testing performed by a NRTL → Listed and Labeled
- Designates ceiling fans into two categories
  - Safe to mount with blades ≥7 ft (2.1m) blade height - “Residential”
  - Safe to mount with blades ≥10 ft (3.05m) blade height - “Non-residential”
  - Classification based on blade thickness and tip speed

Table 90.1
Ceiling-suspended fans from 2.1 meters (7 feet) to less than 3.05 meters (10 feet) above floor

Air flow	Maximum speed at tip of blades,		Minimum thickness of edges of blades,	
	m/s	(feet per minute)	mm	(inch)
Downward	16.3	(3200)	3.2	(1/8)
Downward	20.3	(4000)	4.8	(3/16)
Upward	16.3	(3200)	4.8	(3/16)
Upward	12.2	(2400)	3.2	(1/8)

ASHRAE 90.1-2019

Where to find out more - [Preview ASHRAE Standards (Free)]

- Definition
  - Ceiling fan, large-diameter: a ceiling fan that is greater than or equal to 84.5 inches (2.15 m) in diameter.
- Section 6 - 6 HEATING, VENTILATING, AND AIR CONDITIONING

  Section 6.4 - MANDATORY PROVISIONS

  6.4.1.3 Ceiling Fans

  Large-diameter ceiling fans shall be rated in accordance with 10 CFR 430 Appendix U or AMCA 230. The following data shall be provided:

  a. Blade span (blade tip diameter).
  b. Rated airflow and power consumption at the maximum speed.

  6.4.1.3.1 The data provided shall meet one of the following requirements:

  1. is determined by an independent laboratory; or
  2. is included in a database published by the U.S. DOE; or
  3. is certified under a program meeting the requirements of Section 6.4.1.5.

International Mechanical Code 2018

- Definition
  - High-volume, large-diameter fans: a low speed ceiling fan that circulates large volumes of air and is greater than 7 feet (2134 mm) in diameter.
- Section 929 High-Volume Large-Diameter Fans

  929.1 General

  When provided, high-volume large-diameter fans shall be tested and labeled in accordance with AMCA 230, listed and labeled in accordance with UL 507, and installed in accordance with the manufacturer's instructions.

Where to find out more - ICC IMC 2018

Where to find out more - NFPA Website

NFPA 13 (11.1.7 & 12.1.4) & 72

NFPA 13

11.1.7 High Volume Low Speed (HVLS) Fans. The installation of HVLS fans in buildings equipped with sprinklers, including ESFR sprinklers, shall comply with the following:

(1) The maximum fan diameter shall be 24 ft (7.3 m).

(2) The HVLS fan shall be centered approximately between four adjacent sprinklers.

(3) The vertical clearance from the HVLS fan to sprinkler deflector shall be a minimum of 3 ft (0.9 m).

(4) All HVLS fans shall be interlocked to shut down immediately upon receiving a waterflow signal from the alarm system in accordance with the requirements of NFPA 72.

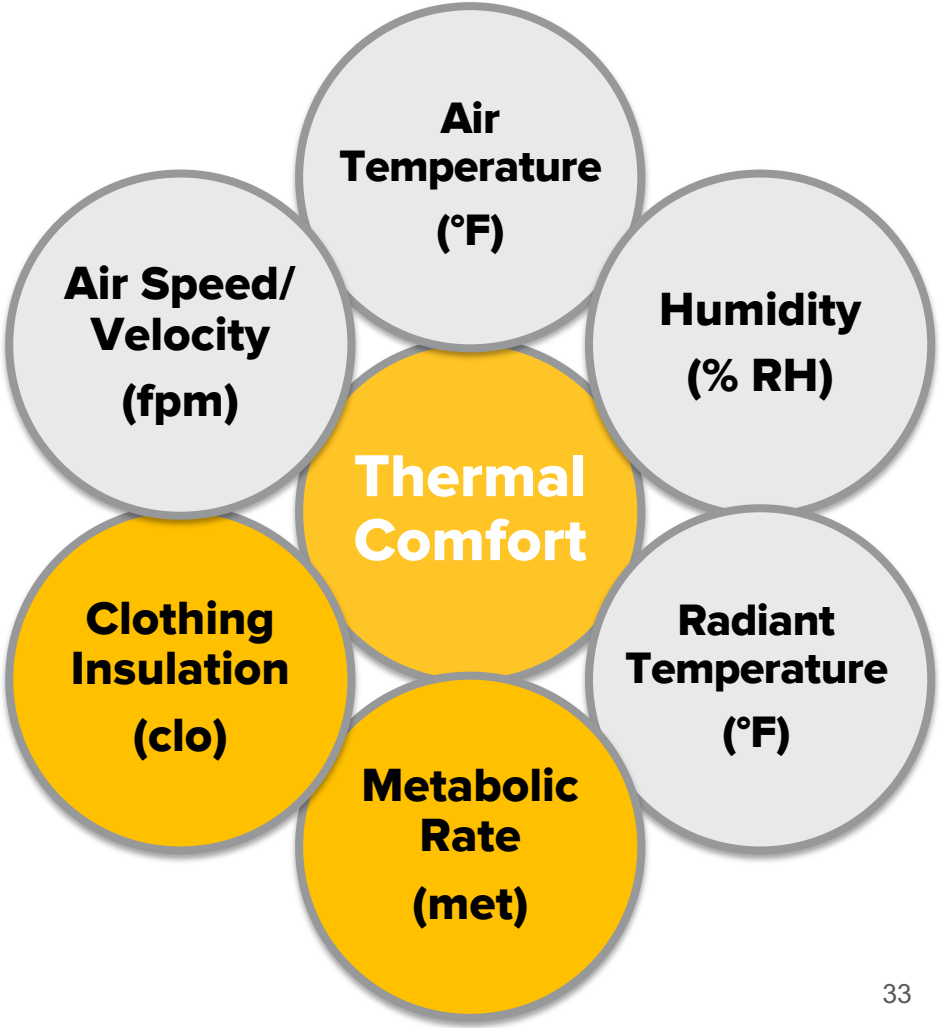
NFPA 72

Where required by NFPA 13, all HVLS large-diameter ceiling fans shall be interlocked to shut down upon actuation of a sprinkler waterflow switch that indicates waterflow in the area served by the fans.

ASHRAE Standard 55-2023

- 6 comfort factors combined
  - 2 Personal
  - 4 Environmental
- Predicts comfort for groups of people
- 80%+ acceptability goal
- Comfort Criteria
  - Predicted Mean Vote (PMV)
  - Predicted Percentage of Dissatisfied (PPD)
  - Standard Effective Temperature (SET)
- Design standard for occupant comfort
- CBE at Cal Berkeley Comfort Tool

Where to find out more - [CBE Thermal Comfort Tool]



CBE Thermal Comfort Tool

Help Other CBE tools

CBE CENTER FOR THE BUILT ENVIRONMENT

ASHRAE-55 EN-16798 Compare Ranges Upload Fans & Heat PHS

Compare comfort conditions

Inputs #1 Inputs #2 Inputs #3

	Inputs #1	Inputs #2
Air temperature	75 °F	80 °F
Mean radiant temperature	75 °F	80 °F
Air speed	20 fpm	150 fpm
Relative humidity	50 %	50 %
Metabolic rate	1.1 met	1.1 met
Clothing level	0.8 clo	0.8 clo

Relative hun

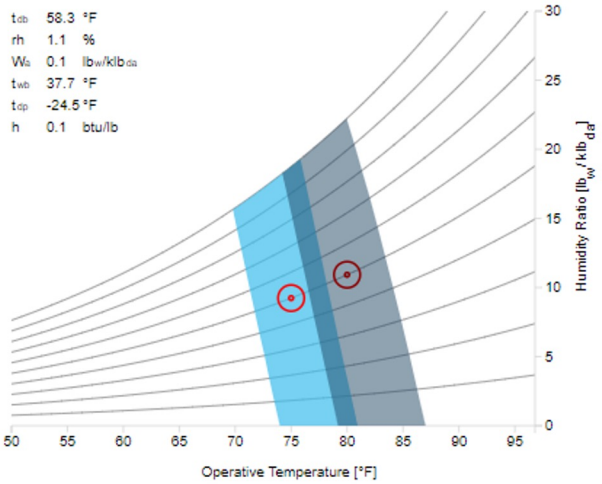
Reset Set pressure SI/IP

☐ Use operative temp

Documentation

	#1	#2
Compliance	✔	✔
PMV with elevated air speed	0.00	-0.01
PPD with elevated air speed	5 %	5 %
Sensation	Neutral	Neutral
SET	77.5 °F	77.5 °F
Dry-bulb temp at still air	75.0 °F	74.4 °F
Cooling effect	0.0 °F	5.6 °F

Psychrometric (operative temperature)



LDCF Performance Data Summary

	US DOE	AMCA CRP	ASHRAE 55 & 216P
Primary Purpose	Min Effic to Sell in US & Accurate Published Data	Accurate Data	Selection of Product
Method of Test	Based on AMCA 230-15	AMCA 230-15	ASHRAE 216
Primary Data	Power & Airflow	Power & Airflow (no sound currently)	Air Speed & Cooling Effect
Third Party Verification	Yes	Yes	No
Performs Primary Testing	No	Yes	N/A
Market Surveillance	Yes	Yes	N/A
Periodic Reverification	Annual Resubmission	Yes	N/A
Penalty for Violations	Fines, Public Announcement	Public Announcement	N/A
Online Verification Database	CCMS	CRP Database	N/A
Valid Internationally	No	Yes	Yes

Example Specifications

Specifying Accurate Performance Data

1. LDCF shall be tested and performance data determined in accordance with 10 CFR Appendix U to Subpart B of Part 430 - Uniform Test Method for Measuring the Energy Consumption of Ceiling Fans / ANSI/AMCA Standard 230-15.

2. LDCF shall be listed in the US DOE Compliance Certification Database (CCD).

3. LDCF shall exceed the US DOE minimum-efficiency requirement of CFEI 1.00 at high speed and CFEI 1.31 at 40 percent speed or the nearest speed that is not less than 40 percent speed.

4. LDCF shall comply with AMCA Publication 211 and be certified to bear the AMCA Certified Ratings Program seal. They shall be tested for air performance in accordance with ANSI/AMCA Standard 230 / 10 CFR Appendix U to Subpart B of Part 430.

Complying With Additional Codes/Standards

5. The LDCF assembly, as a system (with and without light kit), shall be Intertek/ETL-certified and built pursuant to the guidelines set forth by UL standard 507 and CSA standard 22.2 No. 113.

6. LDCF shall be installed per the requirements of NFPA 13 & NFPA 72.

7. LDCF shall be installed in accordance with manufacturer’s instructions.

Destratification

Destratification (air mixing) selections are typically based on the number of times the volume of air in the space is mixed by the fan in an hour (air turnovers per hour). Generally, the selection is based on fan performance at partial speed (~20% to ~40% of maximum RPM) to avoid causing a draft (air speed exceeding ~40 fpm at the occupant level).

So, for a space that is 1,140,000 cubic feet: Divide by 60 minutes. Multiply two turnovers per hour. You get 38,000 cfm.

Specification - Destratification (items 1-7 above + item 8 below)

8. LDCF shall supply a minimum of two (2) air turnovers per hour (38,000 cfm) of airflow at 20% of the maximum operating speed. Airflow shall be determined using either ANSI/AMCA Standard 230 or 10 CFR Appendix U to Subpart B of Part 430.

Thermal Comfort

Comfort applications are based around the creation of elevated air speed at the occupant level. ASHRAE Standards 55 and 216 should be used as the basis of design for these types of applications. Standard 55 provides the three important factors:

- The heights above the ground that air speed should be measured at (4, 24, and 43 in. for seated occupants and 4, 43, and 67 in. for standing occupants.
- The calculation for average air speed. The spatial average is for the three heights in the first bullet and the air speed is averaged over an interval not less than one and not more than three minutes.
- How to translate average air speed into a cooling effect (typically done using the CBE Thermal Comfort Tool).

https://ashrae.org/technical-resources/standards-and-guidelines

https://comfort.cbe.berkeley.edu/

Thermal Comfort Specification

Basic

8. The LDCF(s) shall generate an average air speed at the occupant level of 125 fpm (as defined in ASHRAE Standard 55) over a floor area equivalent to a circle with a diameter 6 times that of the scheduled LDCF.

Better

8. Ceiling fan sizing, placement, and performance (average air speed at the occupant level of 125 feet per minute or greater) shall be verified using computational fluid dynamics (CFD) analysis. At a minimum, the input data for the CFD analysis shall include the ceiling fan(s), significant obstructions to airflow at the floor level, and the actual space dimensions. As verification of performance, the submittal shall include results of the CFD analysis including, at a minimum, the following performance metrics determined in accordance with ANSI/ASHRAE Standards 55 and 216: average air speed, average cooling effect from elevated air speed, Predicted Mean Vote, and Predicted Percentage Dissatisfied for seated and standing occupants in each occupied zone.

Example HVLS Fan Schedule

HVLS Fans

TAG	MANUFACTURER	MODEL	SIZE	VOLT/PH	WEIGHT (LBS)	MOTOR	MAX RPM	MAX AIRFLOW (CFM)	MAX POWER (W)	CIRCUIT SIZE (AMPS)	CONTROL	NOTES
HVLS-1	Fan Company X	Generic	20'	200-240V/3	220	2.0 HP	70	190,000	1550	15	Wall Control	1-7

TAG	MANUFACTURER	MODEL	SIZE	VOLT/PH	WEIGHT (LBS)	MOTOR	RPM*	AIRFLOW (CFM)*	POWER (W)*	CIRCUIT SIZE (AMPS)	CONTROL	NOTES
HVLS-1	Fan Company X	Generic	20'	200-240V/3	220	2.0 HP	14	38,000	65	15	Wall Control	1-7

* Scheduled RPM, airflow, and power are at 20% of the maximum operating speed.

NOTES:

1. Fan(s) to be installed to meet all MANUFACTURER'S fan clearance guidelines
2. Verify extension tube length and mounting methods with manufacturer prior to ordering
3. Fan(s) to be tied into fire suppression system per NFPA 13 requirements
4. Factory warranty equal to X years mechanical, X years electrical, X year labor. See the complete warranty for more details.
5. The fan assembly, as a system, shall be Nationally Recognized Testing Laboratory (NRTL)-certified and built pursuant to the guidelines set forth by UL standard 507.
5. Ceiling fans greater than 7 feet in diameter shall be tested and performance data determined in accordance with 10 CFR Appendix U to Subpart B of Part 430.
7. Ceiling fans greater than 7 feet in diameter shall exceed the US DOE minimum-efficiency requirements.

To receive PDH credit, you must complete the post-course evaluation