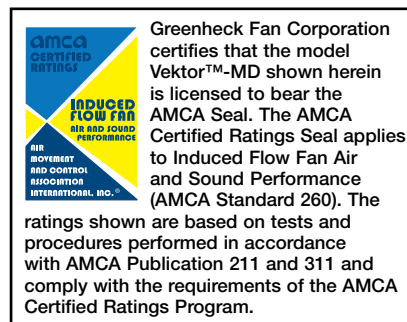
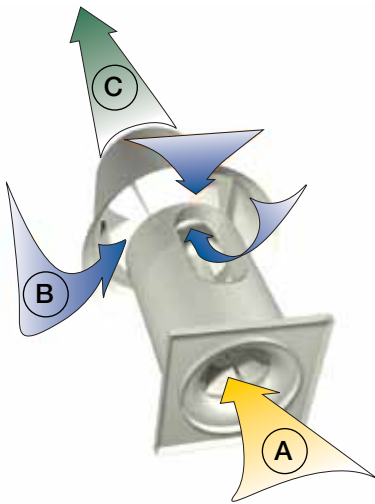


High Plume Dilution - Vektor Laboratory Exhaust System

The Greenheck Vektor™ High Plume Dilution Blower (patented) employs a unique discharge nozzle design that entrains additional ambient air, diluting the exhaust effluent from the laboratory, which reduces exhaust contaminant concentration. More important, the addition of the ambient air increases the Vektor's discharge windband mass flow and velocity, resulting in greater nozzle discharge momentum, displacing the diluted exhaust high above the roof.

How Vektor Technology Works...

Laboratory exhaust is drawn into the Vektor fan (A). The exhaust is discharged into the Vektor induction nozzle and ambient dilution air is induced into the Vektor nozzle (B). The laboratory exhaust plus induced dilution air is discharged at high velocity to atmosphere (C).



Vektor™-MD Inline Mixed Flow High Plume Dilution Blower



Why use the Greenheck Vektor Lab Exhaust System?

The main objective of a laboratory exhaust system is to remove hazardous or noxious fumes from a laboratory, dilute the fumes as much as possible and expel them from the lab building so that the fumes do not contaminate the roof area or become re-entrained into the building make-up air system.

The Greenheck Vektor™ High Plume Dilution Blower is a self-contained laboratory exhaust system, which offers the following benefits:

- Significant plume rise without unsightly exhaust stacks that detract from buildings aesthetics
- Significant dilution of laboratory exhaust, reducing levels of contaminant concentration
- Inline mixed flow configuration
- Reliable belt or direct drive systems
- Efficient and quiet blower technology
- Unique “vacuum shaft seal” ensuring that hazardous or noxious fumes do not escape through the shaft opening (patent pending)
- AMCA class C or B spark-resistant construction
- L₁₀ 200,000 hour minimum life fan shaft bearings
- Premium high-efficiency motor as standard
- Application to constant or variable volume exhaust systems
- Efficient discharge nozzle design
- LabCoat™ a two-part corrosion-resistant baked polyester resin powder coating with zinc-rich epoxy primer
- Safe and easy maintenance
- Flow applications from 1,500 - 80,000 cfm and up to 8 in. ESP per fan
- Multiple fan assemblies on a factory provided common plenum
- Meets ANSI Z9.5, UL 705, and ASHRAE lab design guidelines

No one tests and certifies performance like Greenheck!

Design Features

- Uses roof mounted inline blower to remove and dilute laboratory exhaust
- Ideal for applications:
 - Where roof space is limited (minimal footprint)
 - Demands high levels of exhaust at moderate to high static pressures
- Utilizes mixed flow impeller technology (U.S. Patent 7048499)

Benefits:

- Efficient operation for reduced energy consumption
- Lower overall sound levels - 5-20 dB less than inline centrifugal or axial exhaust fans

Construction:

- Heavy-gauge, welded steel
- Available with AMCA spark C or B construction
- LabCoat™ electrostatically powder coated with corrosion-resistant Hi-Pro Polyester and zinc-rich epoxy primer – Dark Gray 041 (standard)
- Range of optional colors available
- Lifting lugs and guards manufactured with coated stainless or galvaneal steel

Bypass Air Plenums:

- Single or multiple Vektor-MD inline exhaust blowers
- Modular in design to easily adapt to different configurations
- Can be added to a system on retrofits
- Available in single- or double-wall construction
- Designed to handle windloads up to 125 mph without guy wires
- Bypass air and isolation dampers
 - Low-leakage airfoil blades
 - LabCoat™ electrostatically powder coated with corrosion-resistant Hi-Pro Polyester and zinc-rich epoxy primer Dark Gray 041 (standard)
 - Sized specifically for each application
 - Factory-mounted electric or pneumatic actuators available

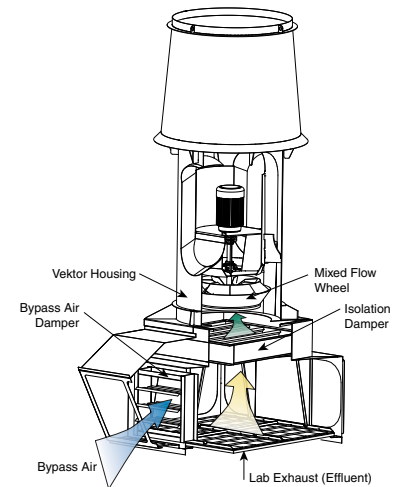
Features

Belt Drive

- AMCA arrangement 9
- Provides safe, easy inspection and maintenance of fan drive components
- Housing is bifurcated with motor, belts, and bearings located outside of contaminated airstream
- Motor or drive replacement does not require removal of fan from the system or exposure to contaminated interior
- Drive sized for 200% of the motor horsepower
- Minimum of two drive belts
- Ability to adjust fan RPM to compensate for system static pressure variations (balancing) and future system performance requirements

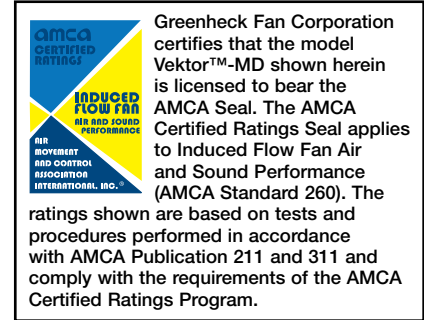
Direct Drive

- AMCA arrangement 2
- Utilizes a unique design offering safe and easy motor replacement
- Utilizes a single rigid self-aligning coupling, connecting the motor shaft to the impeller shaft
- Motor bearings do not support the weight of fan impellers: Longer motor life



Laboratory Exhaust Systems

Model Vektor™-MD



AMCA Induced Flow Licensed

The Air Movement and Control Association (AMCA) International, Inc. has introduced AMCA Standard 260, “Laboratory Methods of Testing Induced Flow Fans for Rating.” Induced flow fans, also known as high plume dilution blowers, are used to dilute hazardous laboratory exhaust and disperse the exhaust high into the atmosphere, away from possible re-entrainment zones. Prior to AMCA Standard 260, high plume dilution blowers fell outside the scope of AMCA performance certification. Now, AMCA Standard 260 can provide consulting and facility engineers independent performance verification for critical laboratory exhaust applications that they insist on for other fans and blowers used in general HVAC applications.

Greenheck's Vektor™-MD is licensed to bear the AMCA Induced Flow Fan Air and Sound Certified Ratings Seal. Each fan size has been tested in our AMCA accredited air and sound laboratory and their performance as cataloged is assured. The AMCA Induced Flow Fan seal encompasses the following AMCA test standards:

- ANSI/AMCA Standard 210, “Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating”
- AMCA Standard 260, “Laboratory Methods of Testing Induced Flow Fans for Rating”
- AMCA Standard 300, “Reverberant Room Method for Sound Testing of Fans”

Visit <http://www.AMCA.org> for more information regarding AMCA Standards and Publications.

Laboratory Exhaust System Terminology

Bypass Air - Ambient air that is drawn through the bypass air plenum and mixed with the lab exhaust to increase dilution and plume rise. Bypass air is primarily utilized in variable volume applications to maintain a constant discharge volume.

Dilution - The ratio of the total fan outlet volume to the lab exhaust volume.

Effective Plume Height - Sum of the discharge plume rise, plus the added height of the laboratory exhaust system above the roof-deck level. (See diagram on page 6)

Entrained Air - Air that is drawn through the windband and mixed with the lab exhaust to increase the dilution and plume rise.

Lab Exhaust - Air that is being exhausted from the laboratory.

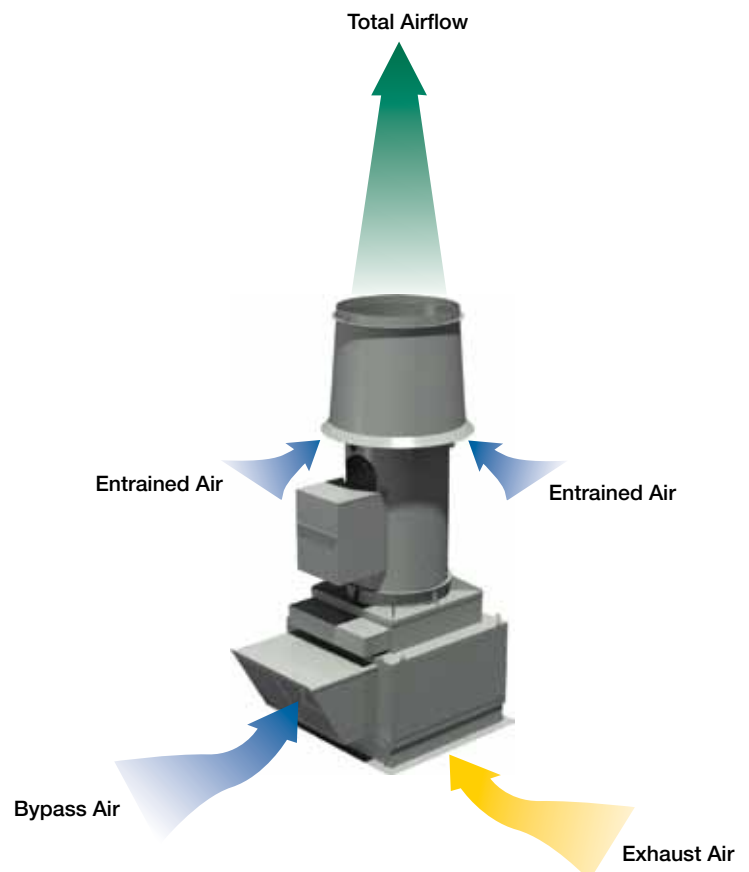
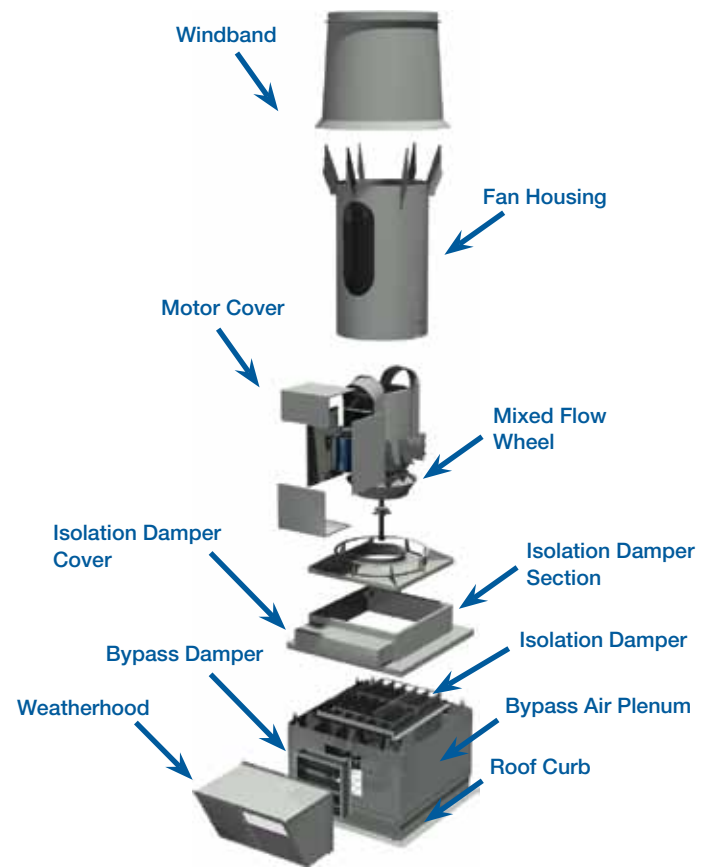
Nozzle - Located at the discharge of the fan housing, the nozzle is used to accelerate the exhaust air as it enters the windband.

Plume Rise - The height of the propelled lab exhaust and dilution air above the discharge of the windband.

Total Airflow - The sum of the lab exhaust, bypass air, and entrained air.

Windband - Device used to direct the lab exhaust as it leaves the housing of the exhaust fan and entrain dilution air.

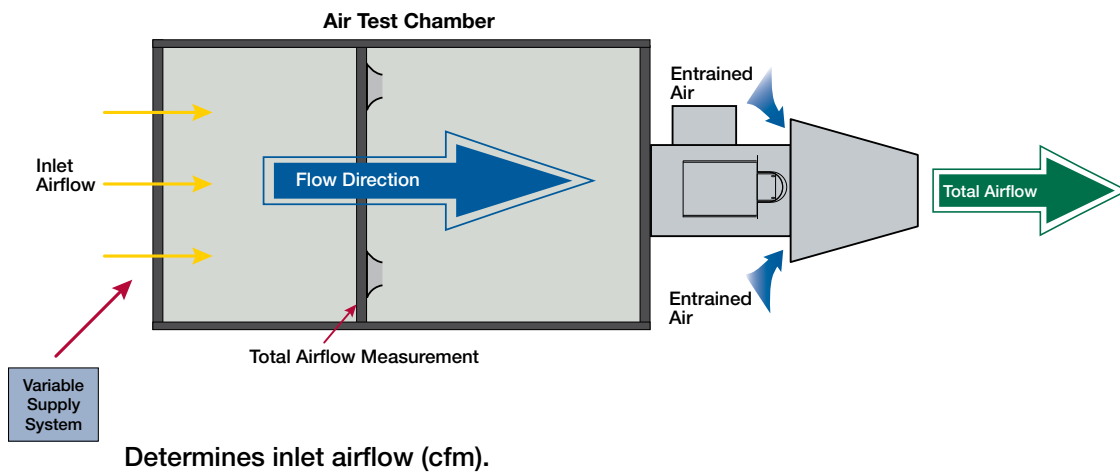
Variable Nozzle Technology (VNT) - Greenheck Vektor-MD exhaust fans offer multiple nozzles and windbands to optimize the plume rise, efficiency, and sound levels of the fan. Greater nozzle velocities result in increased air entrainment and higher plume rise.



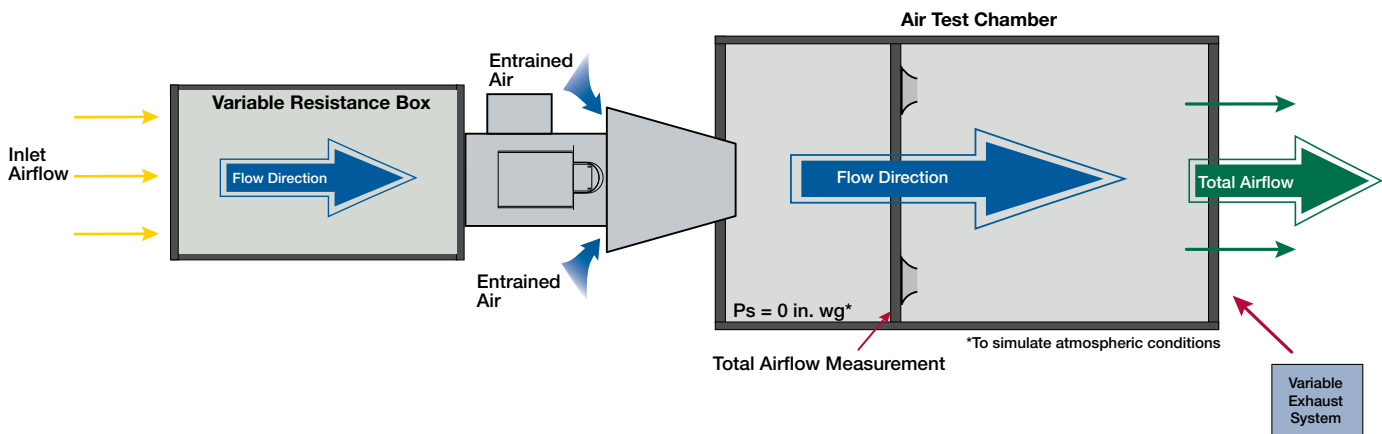
The following illustrations describe the procedure for determining the total laboratory exhaust fan discharge flow. The total discharge flow is the sum of inlet airflow and entrained airflow. The key requirement to AMCA 260 is the variable resistance box. This box allows the measurement of total discharge flow ($P_s = 0$ in. wg to simulate discharging the fan to atmosphere) at all points along its fan curve.

Without the variable resistance box, the entrained airflow can only be measured at the free air point of its fan curve. The entrained airflow obtained can be used to calculate an effective plume height. Therefore, AMCA 260 certification is necessary to ensure the laboratory exhaust fan specified is providing the plume rise and entrainment submitted.

ANSI/AMCA 210 Figure 15 Test

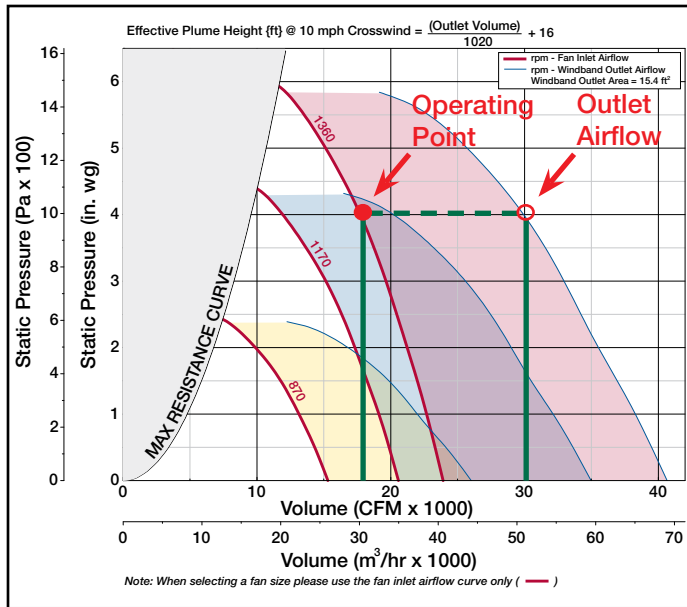


AMCA 260 Figure 1 Test



Determines outlet airflow (cfm) at the same inlet conditions measured in the Figure 15 test.

The entrainment ratio can be determined by dividing the outlet airflow from the AMCA 260 Figure 1 test, by the inlet airflow from the AMCA 210 Figure 15 test.



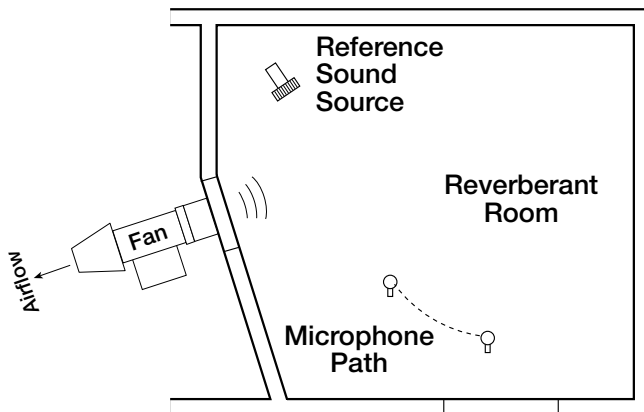
$$\text{Entrainment Ratio} = \frac{\text{Outlet Airflow}}{\text{Inlet Airflow}} \text{ or } \left(\frac{\text{Figure 1 test}}{\text{Figure 15 test}} \right)$$

$$\text{Entrainment Ratio} = \frac{30,000 \text{ cfm}}{17,500 \text{ cfm}} = 171 \%$$

AMCA 300 Sound Test Procedure

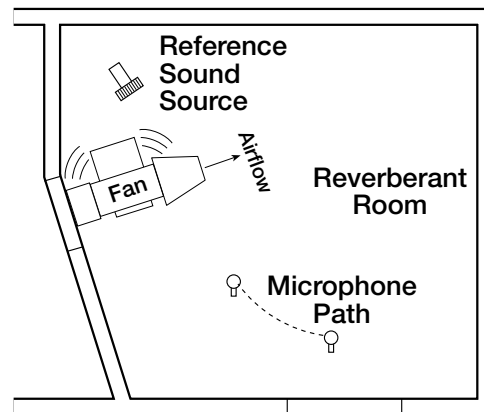
Greenheck is the first company in the laboratory exhaust fan industry to receive AMCA 260 certification and is also leading the industry when it comes to sound testing. Greenheck tests the outlet sound of the fan with the entire fan located inside the reverberant room according to AMCA 300 Figure 3 below.

Inlet Sound



AMCA 300 Figure 2: Fan Inlet Testing
(Installation Type A: Free Inlet, Free Outlet)

Outlet Sound



AMCA 300 Figure 3: Fan Outlet Testing
(Installation Type A: Free Inlet, Free Outlet)

All Vektor-MD high plume dilution blowers have been tested in our third party accredited sound laboratory and their performance as cataloged is assured.

Effective Plume Height

It is important that the exhaust plume height be great enough to avoid re-entrainment of exhaust air and to disperse the exhaust. The effective plume height should be used when analyzing design issues. The effective plume height (h_e) is the physical height of the fan system (h_s) plus the plume rise (h_r), found from the equation below.

The effective plume height is calculated using the following equation*:

$$h_e = h_r + h_s$$

$$h_e = [3.0 \times (V \times d / U)] + h_s$$

Note: Fan curves include effective plume height equations that are specific to the fan size located in the air data section of this catalog.

h_s = fan height (dimensions section of this catalog)

h_r = plume rise, ft (m)

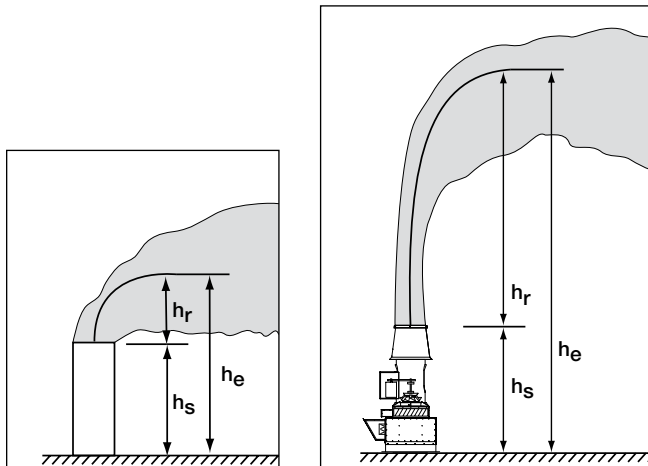
V = windband exit velocity, ft/min (m/s)

d = windband diameter, ft (m)

U = wind speed, ft/min (m/s)**

* From ASHRAE Laboratory Design Guide, Equation 9-2

** Plume rises shown on performance pages are calculated with a 880 ft/min, [10 mph], (4.47 m/s) crosswind.



Note: Graphical comparison of Vektor-MD to low velocity, traditional stack.

Quick Select Chart					
Fan Size	Laboratory Exhaust		Effective Plume Height h_e		
		cfm	m ³ /h	ft.	m
15	Min	1,300	2,200	17	5.2
	Max	5,500	9,300	34	10.4
16	Min	1,600	2,700	19	5.8
	Max	7,000	11,900	39	11.9
18	Min	2,000	3,400	21	6.4
	Max	8,500	14,400	42	12.8
20	Min	2,500	4,200	22	6.7
	Max	10,500	17,800	47	14.3
22	Min	5,000	8,500	27	8.2
	Max	14,000	23,800	50	15.2
24	Min	6,000	10,200	28	8.5
	Max	17,500	29,700	52	15.9
27	Min	7,500	12,700	32	9.8
	Max	20,000	34,000	55	16.8
30	Min	9,000	15,300	34	10.4
	Max	25,000	42,500	62	18.9
33	Min	8,000	13,600	31	9.5
	Max	30,000	51,000	61	18.6
36	Min	9,500	16,100	33	10.1
	Max	35,000	59,500	65	19.8
40	Min	12,000	20,400	36	11.0
	Max	44,000	74,800	73	22.3
44	Min	14,000	23,800	40	12.2
	Max	54,000	91,700	75	22.9
49	Min	17,500	29,700	44	13.4
	Max	66,000	112,100	83	25.3

Note: Plume rise ranges shown above are based on 3,000 fpm (15.25 m/s) minimum discharge velocity per ANSI Z9.5 with a 10 mph (16.09 km/hr) crosswind per ASHRAE Applications Handbook.

Note: When manually selecting a fan it is important to remember that more than one fan is available to meet the desired performance. Selection criteria such as fan size, efficiency, speed, outlet velocity, horsepower, sound, or construction material may also dictate which fan is chosen.

Adjusting Plume Height

Adjusting the fan system to have additional throw or plume height is achieved by increasing the volume of air through the discharge nozzle. Simply changing the drive pulleys will increase fan speed and volume capacity, thus boosting flow momentum. The additional air through the fan comes from an increase in lab exhaust or an increase of air through a bypass air damper. Utilizing a bypass air damper to increase both dilution and mass flow of the exhaust air can optimize plume rise. Increased mass flow improves momentum and carries the diluted exhaust higher.

The plume height can also be adjusted by changing nozzles. A higher velocity nozzle results in higher outlet airflow, which in turn results in higher plume rise.

Air Temp. °F	Elevation (Feet Above Sea Level)															
	0	1000	2000	3000	4000	5000	6000	7000	8000	9000	10000	11000	12000	13000	14000	15000
-20	0.83	0.86	0.89	0.93	0.96	1.00	1.03	1.07	1.11	1.15	1.19	1.24	1.28	1.33	1.38	1.43
-10	0.85	0.88	0.91	0.95	0.98	1.02	1.06	1.09	1.14	1.18	1.22	1.27	1.31	1.36	1.41	1.46
0	0.87	0.90	0.93	0.97	1.00	1.04	1.08	1.12	1.16	1.20	1.25	1.29	1.34	1.39	1.44	1.50
10	0.89	0.92	0.95	0.99	1.03	1.06	1.10	1.14	1.19	1.23	1.28	1.32	1.37	1.42	1.47	1.53
32	0.93	0.96	1.00	1.04	1.07	1.11	1.15	1.20	1.24	1.29	1.33	1.38	1.44	1.49	1.54	1.60
50	0.96	1.00	1.03	1.07	1.11	1.15	1.20	1.24	1.29	1.33	1.38	1.44	1.49	1.54	1.60	1.66
70	1.00	1.04	1.08	1.12	1.16	1.20	1.24	1.29	1.34	1.39	1.44	1.49	1.55	1.60	1.66	1.72
100	1.06	1.10	1.14	1.18	1.22	1.27	1.31	1.36	1.41	1.47	1.52	1.58	1.63	1.69	1.76	1.82
125	1.10	1.14	1.19	1.23	1.28	1.32	1.37	1.42	1.48	1.53	1.59	1.65	1.71	1.77	1.84	1.90
150	1.15	1.19	1.24	1.28	1.33	1.38	1.43	1.48	1.54	1.60	1.66	1.72	1.78	1.85	1.91	1.98
175	1.20	1.24	1.29	1.34	1.39	1.44	1.49	1.55	1.60	1.66	1.72	1.79	1.85	1.92	1.99	2.07
200	1.25	1.29	1.34	1.39	1.44	1.49	1.55	1.61	1.67	1.73	1.79	1.86	1.93	2.00	2.07	2.15

Density Correction Factor Equation

$$DCF = ((T + 460)/530) \times 1.037(E / 1000)$$

DCF = Density Correction Factor

T = Temperature (degrees F)

E = Elevation above sea level (feet)

Air Density (lb/ft³) = 0.075 / DCF

Effects of Air Density

When selecting a fan to operate at a non-standard air density using standard air density tables and curves, corrections must be made to static pressure and brake horsepower.

At higher than standard elevations and temperatures, air density will be lower than standard. Therefore, static pressure must be determined at standard density that will equate to the specified static pressure at the operating density. Since standard air density is greater than operating air density in this instance, one would expect the corrected static pressure to be greater than the operating static pressure.

The following example shows how to select a Vektor-MD Size 30, 85% Wheel Width, Low Velocity (LV) Nozzle for 17,000 cfm, 4 in. wg, 1000 ft. elevation, and 125°F temperature.

1. Since the volume exhausted by the system is not affected by density, cfm remains 17,000.
2. Select the correction factor from the chart for 1000 ft. elevation and 125°F. Correction factor is 1.14.
3. Multiply specified static pressure (4 in. wg) by the correction factor (1.14) to determine standard air density equivalent static pressure. {4 in. wg x 1.14 = 4.56 in. wg}
4. Using the performance curves, enter 17,000 cfm and 4.56 in. wg of static pressure.
5. At the intersection of 17,000 cfm and 4.56 in. wg static pressure, the fan rpm is approximately 1450 rpm and Bhp is 20.
6. Since the horsepower selected refers to standard air density, this must be corrected to reflect actual Bhp at the lighter operating air. Remember, horsepower is less at a lower air density. Divide the Bhp required (20) by the correction factor (1.14) selected previously to determine the Bhp at the new operating conditions.
20/1.14 = 17.5 Bhp. This would require a minimum motor size of 20 hp.

Vektor-MD Selection: AMCA 260 Inlet Airflow Curves

Every laboratory or fume exhaust application has a unique set of criteria that must be evaluated in order to determine the most effective exhaust system. The selection of a Vektor-MD requires the lab exhaust volume (effluent) per fan along with a determination of the external static pressure. Other considerations when making fan selections include: sound requirements, electrical limitations, size constraints, and the effective plume height.

1) Determine the laboratory exhaust requirements

- Determine the lab exhaust volume per fan.
- Determine the external static pressure at the system inlet.

Bypass Air Plenums - Estimated Pressure Drop

- Variable volume lab exhaust systems require a bypass air plenum and damper.
- Greenheck's Computer Aided Product Selection (CAPS) software, automatically adds external system static pressure to account for the bypass air plenum and isolation damper.

2) Select the appropriate Vektor-MD

Select Vektor-MD fans with a minimum nozzle velocity of 3,000 feet per minute (ANSI Z9.5 and ASHRAE lab design guidelines), which is represented by the green vertical line in Figure 1.

- (A)** All Vektor-MD curves indicate the minimum cfm necessary to meet this minimum velocity.

3) Determine fan rpm

- Locate the fan operating point (the intersection of the required airflow and static pressure) on the inlet airflow in Figure 1.

(B) In this example, the operating point is 17,500 cfm at 4 in. wg.

The belt drive fan rpm can be estimated by comparing the operating point to any of the solid fan rpm curves and in this example, the operating point falls on the red 1360 rpm curve.

(C) Direct drive fan selections must use the 50 or 60 cycle rpm curves (yellow or blue curves).

- Determine the brake horsepower by comparing the operating point to the dashed brake horsepower curves.

In this example, the brake horsepower is above 15, but slightly less than 20 hp. A minimum of a 20 hp motor is recommended for this selection.

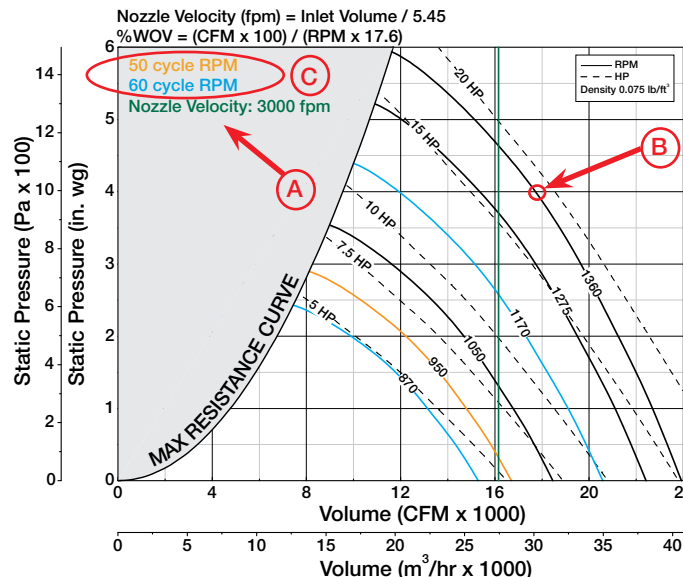
4) LV, MV and HV Nozzles

Each fan size is available with Low Velocity (LV), Medium Velocity (MV) or High Velocity (HV) nozzles.

- Multiple nozzles allow for the optimization of brake horsepower, plume rise and acoustic performance.

Note: For most applications, the LV or MV nozzles are recommended in order to limit the operating brake horsepower. HV nozzles are available for applications that require the highest plume rise.

Figure 1: Vektor-MD Size 30 Low Velocity 100% Wheel Width



Vektor-MD Selection: AMCA 260 Outlet Airflow Curves

Figure 2 below illustrates the new AMCA 260 fan curves. Each fan has two performance curves associated with each rpm: the red curve is the flow through the fan and the blue curve directly to the right is the windband exit volume. These curves have been connected with shading.

1) Determining windband exit volume

- Find the operating point (E). Draw a horizontal line to the right from (E) to the blue windband exit curve (F).
- The windband exit volume is determined by (F), so the windband exit volume is 30,000 cfm.

2) Determining windband velocity, dilution ratio and effective plume height

Each Vektor-MD size and nozzle combination has a unique set of equations to determine the nozzle velocity, dilution ratio, and effective plume height. Since the operating point is 17,500 cfm at 4 in. wg, calculations are as follows for a Vektor-MD Size 30-LV.

$$\text{Windband Exit Volume} = 30,000 \text{ cfm}$$

$$\text{Nozzle Velocity} = 17,500 \text{ cfm} / 5.45 \text{ ft}^2 = 3211 \text{ ft/min}$$

$$\text{Dilution Ratio} = \text{Windband Exit Volume} / \text{Fan Inlet Airflow} = 30,000 \text{ cfm} / 17,500 \text{ cfm} = 171\%$$

$$\text{Effective Plume Height} = \left(\frac{\text{Outlet Volume}}{1020} \right) + 16$$

$$\left(\frac{30,000}{1020} \right) + 16 = 45 \text{ ft}$$

Note: Effective Plume Height includes the fan height of 16 ft. as indicated in the dimensions section of this catalog.

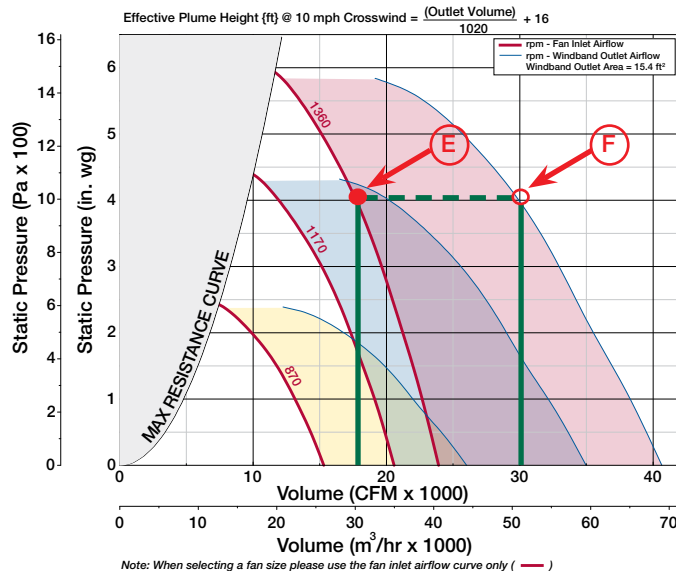
Determining Inlet and Outlet Sound

Along with the fan rpm, it is necessary to know the fan percent wide open volume (%WOV). The %WOV can be calculated using the equation posted adjacent to each fan curve.

$$\%WOV (\text{Vektor-MD-30-LV}) = (\text{cfm} \times 100) / (\text{rpm} \times 17.6). \text{ For this example, the \%WOV is } 73\%.$$

The sound power and sound pressure can be determined through linear interpolation between sound data provided at 1170 rpm and 1360 rpm.

Figure 2: Vektor-MD Size 30 Low Velocity 100% Wheel Width



Vektor-MD Selection: Reading Fan Curves

There are several variables in selecting an appropriate Vektor-MD system including % wheel width and nozzle size. These factors will affect the required brake horsepower, fan RPM, and entrained air. As a general rule, the low velocity nozzle will require less brake horsepower than the high velocity nozzle, but entrained air and plume rise will be slightly less. Higher pressures can be achieved by using reduced % wheel widths. Belt drive units are available in 100%, 85%, and 70% wheel width. Direct drive units are available from 100% - 50% wheel width in increments of 5% (i.e. 95%, 90%).

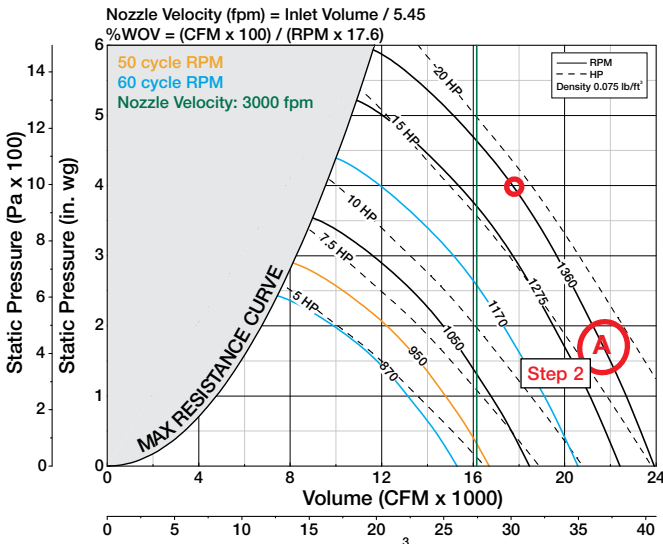
Step 1: Identify necessary laboratory effluent (CFM), plume rise (ft), and % dilution. Enter the Vektor-MD quick select chart located on page 8 and identify unit sizes that can accommodate application specifications. Also determine if belt or direct drive is desired. For direct drive units, only the blue RPM curves are available for 60 cycle power and gold curves for 50 cycle power. Belt drive units are capable of operation at any RPM within the max fan class RPM (the last RPM curve).

Step 2: Using the guidelines above, locate fan size that generally suits specifications. Calculate necessary system pressure including isolation damper, bypass air plenum, and system drop. (See below) Enter the fan curve with the desired performance specifications: airflow (CFM), pressure (in. wg), and nozzle outlet velocity (fpm). This yields horsepower (HP) and RPM at the fan operation point. If the given point has a close proximity to a horsepower curve, the next larger motor horsepower should be selected.

Pressure Drop

Variable volume lab exhaust systems and systems that require additional bypass air, require a bypass air damper and plenum. When calculating necessary pressure, 0.2 in. wg must be added to the external system static pressure to account for the bypass air plenum. Add 0.15 in. wg if the system includes an isolation damper.

Vektor-MD Size 30



NOTE: All plots represent fan operation at standard air (70°C at sea level). ANSI Z9.5 specification requires a 3,000 fpm minimum nozzle outlet velocity.

Example A:

- Lab system A requires 17,500 cfm exhaust, 56 ft. plume rise, with an external static pressure of 4 in. wg.
- From the quick select chart, applicable unit sizes range from Vektor-MD size 24 to Vektor-MD size 44.
- Considering the desired performance criteria, a Vektor-MD size 30 Belt drive with 100% wheel width and low velocity nozzle (LV) is selected to optimize unit size and required horsepower.
- Locating this point on the curve (A), a 20 HP motor is needed to operate at 1360 RPM and provides 3,211 fpm nozzle velocity.
- Using the %WOV equation provided with the Vektor-MD size 30, 100% wheel width, LV nozzle air data chart, the %WOV can be calculated:
 $\%WOV = (17,500 \times 100) / (1360 \times 17.6) = 73 \% \text{WOV}$

Vektor-MD Model Guide

Vektor-MD-15-9-85-LV-HVW

Vektor MD - Mixed Flow,
 High Plume Dilution
 Fan Size — Sizes 15 - 49
 Fan Arrangement
 9 = Belt Drive
 2 = Direct Drive

Windband Type
 HVW = High Velocity Windband
 HPW = High Plume Windband
 Nozzle Type
 LV = Low Velocity
 MV = Medium Velocity
 HV = High Velocity
 Wheel Width
 50 - 100% in increments of 5%