TB-2008-002
Fan Selection Guide
Basic Fan Technology Overview
Technical Terms

Air Flow - CFM : Cubic Feet per Minute or CMM: Cubic Meters per minute
This refers to the volume of air a fan is able to move over time.

Static Pressure-Inch Aq: Inches of Water or Pa” Pascal or Newton per meter squared
This is the total resistive pressure the flow must fight against due to upstream (inlet) and downstream (outlet) obstructions and ducting design.

RPM : Revolutions Per Minute
This refers to how fast the fan or motor is spinning. This has a direct connection to the static pressure and volume of air it can move.

Density
The flow, pressure or head, needs to be specified at a given air/gas density which is affected by temperature and altitude.

Blower
Many types of fans are often referred to as blowers.

Wheel
In centrifugal fans and line blowers the impellers are frequently referred to as wheels.
Four main types of fans

- **Line Blowers (Cross Flow Fans)**
  - Low Pressure / Low to High Volume
  - Airflow distributed along a line or plane

- **Axial Fans**
  - Low Pressure / High Volume
  - Flow axis is coincident to motor axis

- **Centrifugal Fans**
  - High Pressure / Low Volume
  - Flow axis is orthogonal to motor axis

- **Mixed Flow Fans**
  - Medium Pressure / Volume
  - High Efficiency / Low Noise
Axial fans are efficient high volume low pressure machines. These fans are good for general purposes: avionics/electric or personnel cooling; AC and ECS systems, especially if a fan is needed to move air through a heat exchanger.

These fans are also ideal for scavenging as the parts that come in contact with the air/sand mixture are more easily hardened than the complex shapes of other types of fans.
Axial fans come in two types, Vane-axial and Tube-Axial. Vane-axial fans differ from Tube-Axial’s as they have stationary vanes, sometimes called straightening vanes as they “straighten” the air outlet by counteracting the rotational angle from the turning impeller blades.

These vanes allow a higher pressure capability and add efficiency.
Centrifugal Fans

Centrifugal Fans, also called Blowers are used for high pressure, lower flow applications such as NBC and other types of filtration. They are also used for low pressure lower flow general purpose applications as they can be made inexpensively by simple plastic and aluminum parts.
Centrifugal Fans

Centrifugal Fans are also used for AC systems where there is very long ducting that adds up to a lot of pressure drop.
Because the moving parts are covered by the scroll or housing, centrifugal blowers tend to be quieter than other types.
A line blower, is a centrifugal fan in which the air flows through the fan, rather than through an inlet. The rotor of a line blower is covered to create a pressure differential. Line Blowers have a smaller opening on one side and a larger opening on the other. The resultant pressure difference allows air to flow straight through the fan rather than on a rotational angle as in traditional centrifugal fans.
Line Blowers

Line Blowers give airflow along the entire width of the fan along a line or plane depending on how they are installed. Applications include entry doors to exclude particulates and bugs, cooling across circuit cards and electronic equipment where relatively even distribution is required along a plane, and processing equipment where a fluidized bed is required for even gentle vapor extraction or material handling cushioning.
Mixed Flow Fans

Mixed Flow Fans are called mixed as they are a sort of combination axial and centrifugal fan. They are basically Vane-axial fans, but the impeller is shaped like a bevel gear, where the fan blades are at an angle. This means the air is moved by a combination of aero-dynamic/mechanical pushing of air, and the centrifugal action of spinning the air against the housing.

In a blower, the housing is called a scroll, and in the mixed flow, the housing is called a shroud.
Mixed flows are usually made for NBC, or other critical applications for a specific design point where high efficiency and lower noise is required as these tend to be more expensive given their complex design. Mixed-flow fans tend to be quieter than other types because of their efficiency and that their moving parts are partially blocked by the shroud.
Non-Airfoil propellers have blades that are the same thickness the entire length. They are designed to move the air through shear mechanics. This is good for fans that must run at variable speeds.

Airfoil blades have a shape to them much like an airplane wing. These blades are more efficient than non-airfoil; however, they are generally designed for only one point on the performance curve. This makes airfoil fans less versatile.
Tube-Axial vs Vane-Axial

A basic fan is a propeller / impeller mounted on a motor shaft.

Add a housing around the propeller and motor and you have a “tube axial”.

Add “guide vanes” also called “straightening vanes” and you have a vane axial fan.
Types of Fan Motors

**Electric Motor** (single speed or multi-speed)
- A.C. Motor
  - Single Speed
  - Multi-Speed
- D.C. Motor
  - Brush-Type
  - Brushless

**Direct Drive** (no self contained fan motor)
This is simply an impeller mounted on a drive shaft with a set of bearings within a housing. The drive shaft can be coupled to any rotating driver from the system.

**Hydraulic**
Once used for variable speed, these are not recommended. They are expensive, have long lead times, and leak.
Variable speed is best achieved using brushless DC or inverter driven AC motored fans.
FAN LAWS

\[
\frac{\text{RPM}_1}{\text{RPM}_2} = \frac{\text{CFM}_1}{\text{CFM}_2} = 10\% \text{ INCREASE IN RPM}
\]

\[
\left(\frac{\text{RPM}_1}{\text{RPM}_2}\right)^2 = \frac{P_1}{P_2} = 10\% \text{ INCREASE IN RPM}
\]

\[
\left(\frac{\text{RPM}_1}{\text{RPM}_2}\right)^3 = \frac{W_1}{W_2} = 10\% \text{ INCREASE IN RPM}
\]

CFM DOES NOT CHANGE WITH DENSITY.
PRESSURE AND POWER VARY DIRECTLY WITH DENSITY.
BASIC CALCULATIONS

CFM vs MASS FLOW

\[ m(\text{lbs/min}) = \text{air density (lbs/cu ft)} \times \text{cfm} \]

\[ \text{cfm} = \frac{\text{mass flow (lbs/min)}}{\text{air density (lbs/cu ft)}} \]

Example: \[ \frac{50 \text{ lbs/min}}{0.0765 \text{ lbs/cu ft}} = 653.6 \text{ cfm} \]

PRESSURE

1 psi - 27.7 inches of water - 2.036 inches of mercury (in Hg)

Velocity Pressure (Pv)-

\[ \text{velocity squared (v}^2\text{)} \]

\[ 4372@0.0765 \text{ air density} \]
BASIC CALCULATIONS

AIR HORSEPOWER

\[
AHP = \frac{\text{CFM} \times \text{Total Pressure}}{6356}
\]

TOTAL HORSEPOWER

\[
BHP = \frac{AHP}{\text{Fan eff.}} \quad \text{Input HP} = \frac{BHP}{\text{Motor eff.}}
\]
BASIC CALCULATIONS

AIR DENSITY CALCULATION

\[ \rho \text{ (lb/ft}^3) = 0.07647 \times \left( \frac{P}{P_0} \right) \times \left( \frac{T}{T_0} \right) \]
\[ \rho \text{ (kg/m}^3) = 16.0169 \times \rho \text{ (lb/ft}^3) \]
\[ \rho \text{ (lb/ft}^3) = 1.326 \times \text{Pb (in HG)} / (459.7 + T_F) \]
Miscellaneous Considerations

- Fan Testing
- Noise Measurement & Control
- Environmental Considerations
- Inrush Current
Fan Testing

Fan testing at DAE systems is done per the set-up on the next slide. While the instrumentation has been modernized, the basic ASRHA test stand equipment has been in use for decades, allowing consistent test results. Be sure your supplier is willing to demonstrate how their fans were testing to avoid working with someone who “manages results”.

DAE Fan Testing Set Up

PROVISIONS FOR MEASUREMENT OF:

BAROMETRIX PRESSURE
WET AND DRY BULB
TEMPERATURE

TEST CONFIGURATION NO. 1 FOR VANEAXIAL FANS

(D = INSIDE DIAMETER)
Noise data is available at no cost as most fans have the dba on the catalog page. This is the noise measured in the concrete floored test lab at 5 feet at 45 degrees from the fan outlet while in a test duct. This allows comparison to different fans at no cost.

DAE can quote to have our product tested in an independent laboratory in an anechoic chamber according to a defined procedure.
Environmental Considerations & In Rush Current

It is important to specify the ambient temperature and characteristics such as shock, vibration, salt water & high altitude, which may require special design and material.

In rush current for most fans is about 2-3 times full load current and drops to full load typically in about 5-6 seconds.