Industrial Fans

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Air is a Fluid
Birds Swim In It!
40,000 CFM = ? LBS. AIR/HR.
Air = .075 LBS.

1 CU. FT.
40,000 CFM = 90 TONS/HR.
= 3,000 LBS/MIN
Most Common Fan type in the world?

FORWARD CURVED

50 - 60 % efficiency
BACKWARDLY INCLINED
~ 79% max. efficiency
AIRFOIL (BI)
82% max. efficiency
INDUSTRIAL EXHAUSTERS

55-70% EFFICIENCY
AXIAL (PROPELLER) FANS

UP TO 90% EFFICIENCY
INDUSTRIAL FANS

MODULE TOPICS

- FAN IN AIR SYSTEM
- FAN TYPES
- FAN SELECTION
- FAN TESTING
- AIR DENSITY
- FAN SAFETY
The purpose of a fan is to supply an air system with energy (in the form of pressure) necessary to maintain airflow.
FAN TYPES

Centrifugal Fans
- Air turns 90° through the fan.

Axial Fans
- Air Flows straight through the fan.

Other Types
- Special Design Fans.
CENTRIFUGAL FAN TYPES

Different Designs types are used to match System air flow and static pressure requirements.

The Inlet and Outlet Sizes decrease relative to housing diameter as the pressure developed increases.
CENTRIFUGAL FAN TYPES

- Centrifugal Fans used in higher pressure lower flow, corrosive, or material handling systems.
- The Inlet and Outlet Sizes decrease relative to housing diameter as the pressure developed increases.
- Generally outlet velocity Range of 1250 to 6000 FPM Outlet Velocity
- Centrifugal Fan pressure capabilities:
  - Backward Curved Centrifugals up to 20” SP
  - Industrial Exhausters up to 46” SP
  - Pressure Blowers up to 14” SP
  - Turbo Pressure Blowers up to 100” SP
AXIAL FAN TYPES

- Different propeller types are used to match System air flow and static pressure requirements.
- The propeller hub diameter increases relative to the fan diameter as the pressure developed increases.

<table>
<thead>
<tr>
<th>TYPE</th>
<th>PERFORMANCE CURVES</th>
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<tbody>
<tr>
<td>PROPELLER</td>
<td><img src="image" alt="Graph" /></td>
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<tr>
<td>AXIAL FANS</td>
<td><img src="image" alt="Graph" /></td>
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<tr>
<td>VANEXAXIAL</td>
<td><img src="image" alt="Graph" /></td>
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</tbody>
</table>

![Image of AXIAL FAN TYPES with tables and graphs showing performance curves.]
AXIAL FAN TYPES

- Axial Fans used in higher flow lower pressure systems.
- Generally outlet velocity Range of 1000 to 4000 FPM Outlet Velocity
- Axial Fan Pressure capabilities:
  - General Ventilation Fans to 1/2” SP
  - Duct Fans to 1 1/4” SP
  - Duct Axial to 5” SP
  - Vane Axial to 10”
OTHER AIR MOVING DEVICES

Special Designs
- In Line Centrifugal
- Mixed Flow
- Centrifugal Power Roof Ventilators
- Axial Power Roof Ventilators

Ejectors
ACGIH® Velocity Pressure Method Calculation Sheet

- Calculate the required flow through the system.
- Calculate the static pressure required to move the required flow.

\[
\text{SYSTEM SP} = \text{SP}_{\text{out}} - \text{SP}_{\text{in}} - \text{VP}_{\text{in}}
\]

SYSTEM SP provides the Fan SP

\[
\text{SYSTEM CFM} = \text{FLOW}
\]

CFM & SP will develop a System Curve.
FAN SELECTION

- System Calculation
  - Flow or Capacity
  - Pressure Requirements
- System Resistance Curve
- System Losses Plotted

System Loss

\[ \text{System Loss} = C \times VP = C \left( \frac{\text{CFM}}{\text{Area} \times 1097} \right)^2 \times 0.075 = \text{Constant} \times \text{CFM}^2 \]
Select a fan which will generate the required pressure at the desired airflow.
FAN SELECTION

- Other Considerations
- Airstream
  - Materials through the fan
  - Explosive or Flammable Materials
  - Contaminated or Corrosive
  - Elevated Temperature
- Physical Limitations
- Fan Size and Type
- Belt Drive vs. Direct Drive
- Mounting Arrangement
- Materials
- First Cost, Operating Cost, Maintenance Cost
- Other Factors including color
RATING TABLES AND PERFORMANCE PROGRAMS

- Selection and rating areas are defined by the Manufacturers, Usually only good selections are shown.
- Fan Performance tables are at Standard Conditions (0.075 lb./ft.\(^3\) air density.)
- Computer Software is available to provide selections and performance curves.
- The AMCA Certified Rating Program insures manufacturers ratings.
FAN SELECTION

- Ratings will include notes on how the fan was tested
  - Open or Ducted Inlet
  - Open or Ducted Outlet

- Belt losses may not be included in the performance ratings.

- Accessories included in the test
FAN PERFORMANCE

- The Aerodynamic Performance Test
  - AMCA Standard 210 - "Laboratory Methods of Testing Fans for Certified Aerodynamic Performance Rating"
  - AMCA Standard 203 - "Field Performance Measurement of Fan Systems"

- Test Equipment
  - Measure Flow (indirectly)
    - Pitot tube traverse
    - Flow Nozzle
    - Flow Measurement Station
  - Measure Fan Pressure
    - Inlet Pressure
    - Outlet Pressure
  - Measure Fan Power
  - Measure Fan Speed
  - Measure Temperature
    - Dry Bulb Temp.
    - Wet Bulb Temp.
    - Barometric Pressure
    - System Air Temp.
Manufacturers provide fan performance at many speeds and pressures. The Fan Laws are used to calculate performance using well established methods.

All fans have one thing in common:
Accurate prediction of aerodynamic performance requires a test at:
- Constant Speed,
- Known Density
THE FAN LAWS

The Fan Laws are used to calculate fan performance at:
- Other Speeds, Other Densities, Other Fan Sizes

First Law: \[ CFM_2 = CFM_1 \cdot \left[ \frac{DIA_2}{DIA_1} \right]^3 \cdot \left[ \frac{RPM_2}{RPM_1} \right] \]

Second Law: \[ SP_2 = SP_1 \cdot \left[ \frac{DIA_2}{DIA_1} \right]^2 \cdot \left[ \frac{RPM_2}{RPM_1} \right]^2 \cdot \left[ \frac{\rho_2}{\rho_1} \right] \]

Third Law: \[ H_2 = H_1 \cdot \left[ \frac{DIA_2}{DIA_1} \right]^5 \cdot \left[ \frac{RPM_2}{RPM_1} \right]^3 \cdot \left[ \frac{\rho_2}{\rho_1} \right] \]
THE FAN LAWS

Airflow

- Changes in Speed
FAN SELECTION

- Select fan for Stable Operating Point
- Interaction of Fan Performance Curve and System Curve
  - There is only one intersection between the fan curve and system curve.
  - Fans are load matching devices.
- Fans handle ACFM only.
FAN ARRANGEMENT

- AMCA Standard Drive Arrangements: Centrifugal or Axial
- Belt Drive, Direct Drive, and Direct Coupled Arrangements
STANDARD AIR

Standard air is the reference gas for:

- Fan Performance Ratings
- Air System Design

Standard Density is 0.075 lb./ft.³

SCFM is not equal to ACFM
Air Density

- Density effects Fan and System Performance.
- Density at a given temperature and barometric pressure can be calculated:

\[
0.075 \frac{\text{lbm}}{\text{ft}^3} \times \frac{\text{Abs. press.}}{29.92 \text{ in. Hg}} \times \frac{460^\circ F + 70^\circ F}{460^\circ F + \text{Temp.}}
\]
AIR DENSITY

Industrial Ventilation Manual calculates density using Density Factors:

\[
\begin{align*}
\text{df} &= \text{df}_e \times \text{df}_p \times \text{df}_T \times \text{df}_m \\
\text{df}_e &= \left[1 - (6.73 \times 10^{-6})z\right]^{5.258} \\
\text{df}_p &= \frac{(407 + \text{SP})}{(407)} \\
\text{df}_T &= \frac{530}{(T + 460)} \\
\text{df}_m &= \frac{(1 + \omega)}{(1 + 1.607 \omega)}
\end{align*}
\]
FAN SAFETY

- Fans contain moving parts and can be dangerous.
  - Install guards.
  - Know the “Hidden Dangers”
    - Suction and Pressure
    - Windmilling
    - Temperature
    - Noise and Environment
    - Stroboscopic Effect
    - Special Purpose Fans and Systems
  - Have a “lock out” procedure.
- AMCA Publication 410-96, "Recommended Safety Practices For Users and Installers of Industrial and Commercial Fans" is an excellent resource.
CONCLUSION

Proper Fan Application, Selection, Installation, and Maintenance will result in excellent Fan System operations.
Inspection and routine maintenance on a periodic schedule of fan equipment is necessary.

Historical records of fan condition and maintenance should be maintained and compared with current conditions as they are indicators of upcoming problems.

Monitor and record vibration levels.

Sudden changes in fan performance, noise, or vibration levels are often a precursor to breakdown.

Fans should be inspected for condition, material buildup, and erosion.