Fans & Blowers

Twin City

Selecting the Right Fan

Outline

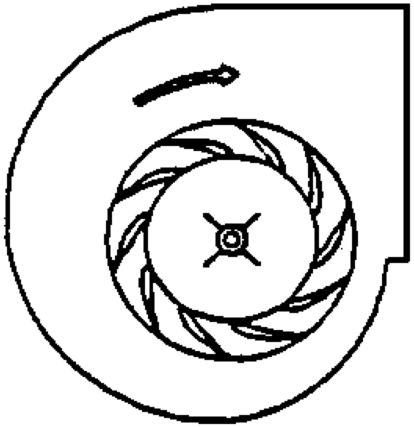
- Fan Types
  - Applications
  - Performance Characteristics
- Fan Construction
  - Drive Arrangements
  - Fan Rotation and Discharge
  - Fan Class of Construction
  - Spark Resistant Construction
  - Special Coatings and Materials
- Fan Selection Considerations
  - Motors
  - V-belt Drives
  - Inlet Vanes

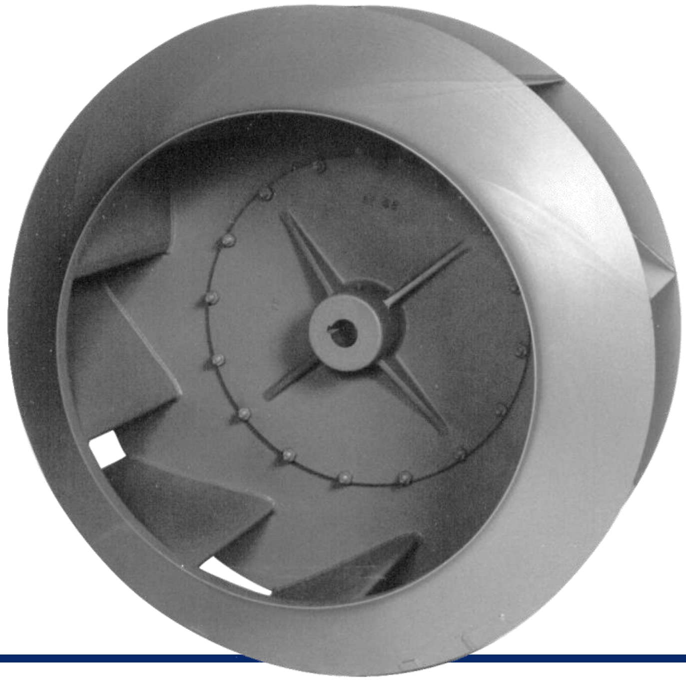
Basic Fan Types

- Centrifugal
  - Backward Inclined Airfoil-blade
  - Backward Inclined Flat-blade
  - Forward Curved Blade
  - Radial Blade
  - Radial Tip
- Axial
  - Propeller / Panel Fan
  - Tubeaxial
  - Vaneaxial
- Special Designs
  - Power Roof Ventilators
  - Tubular Inline Centrifugal
  - Mixed Flow

Backward Inclined - Airfoil Blade

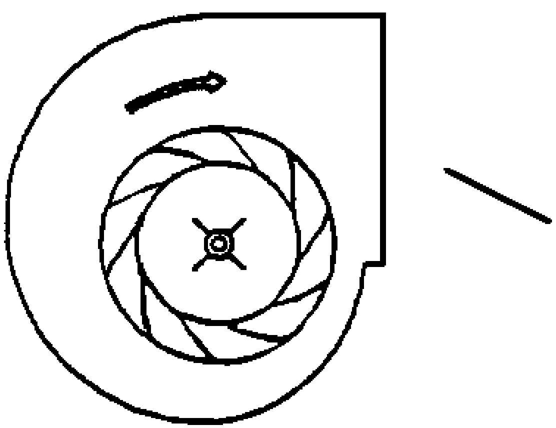
- Name is derived from the “airfoil” shape of blades
- Developed to provide high efficiency
- Used on large HVAC and clean air industrial systems where energy savings are of prime importance





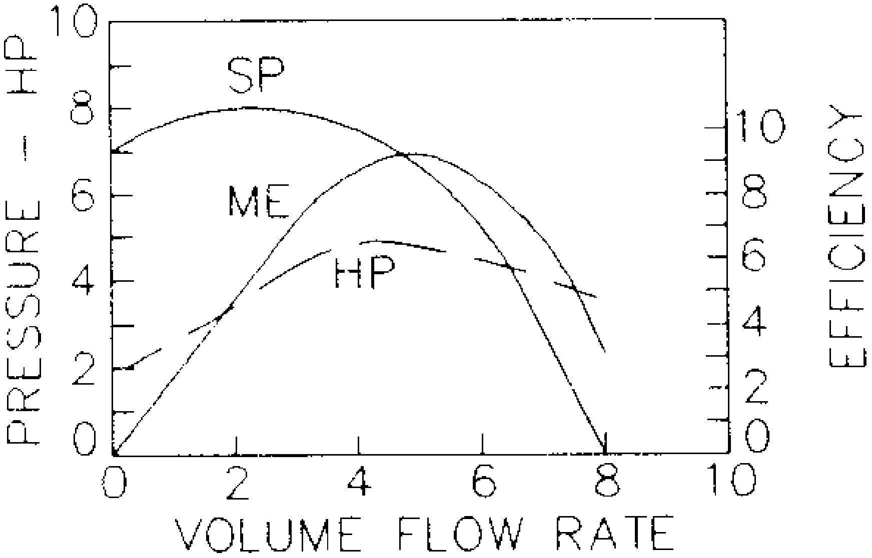
Backward Inclined - Flat Blade

- Backward inclined blades are single thickness or “flat”
- Efficiency is only slightly less than airfoil blade
- Same HVAC applications as airfoil blade
- Also for industrial applications where airfoil blade is not acceptable because of corrosive or erosive environment



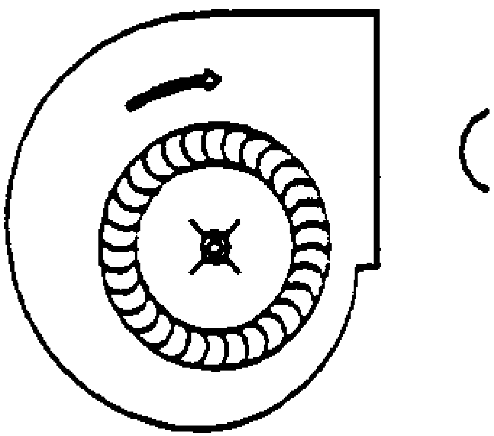
Backward Inclined - Flat & Airfoil Blade

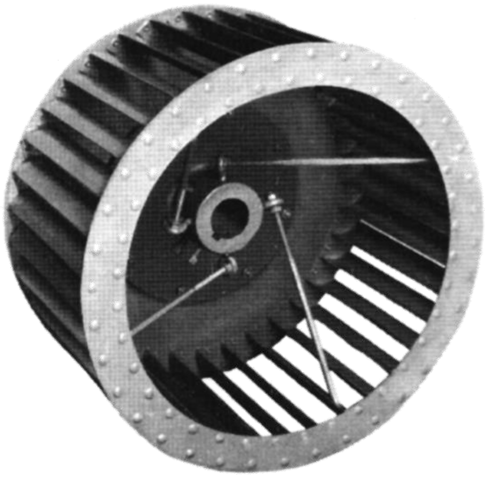
- High volume at moderate pressure
- High speed
- Non-overloading power characteristic
- Low abrasion resistance
- High efficiency
- Stable performance characteristic
- Low noise
- Generally clean air use



Forward Curved Blade

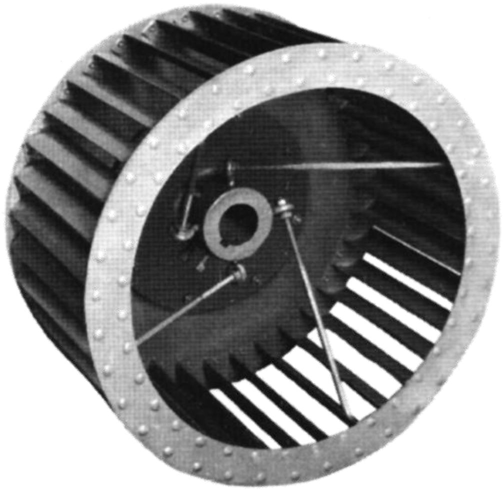
- Blades are curved forward in the direction of rotation
- Less efficient than Airfoil and Backward Inclined
- Requires the lowest speed of any centrifugal to move a given amount of air
- Used for low pressure HVAC systems

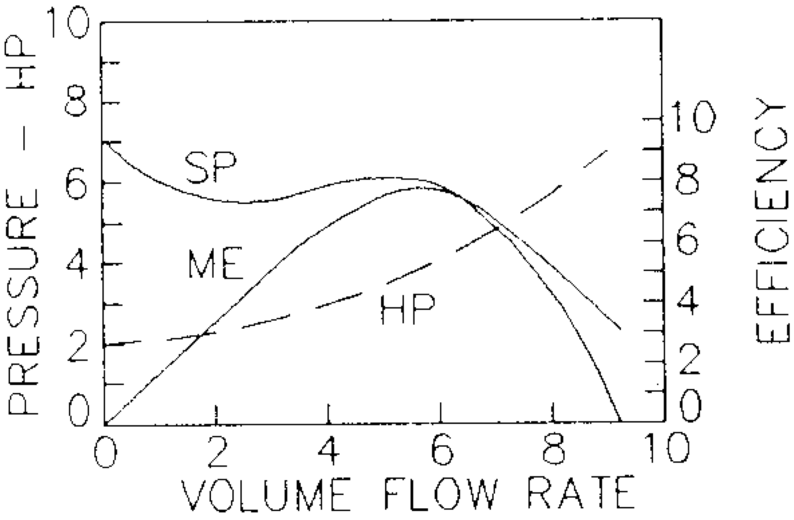




Forward Curved Blade

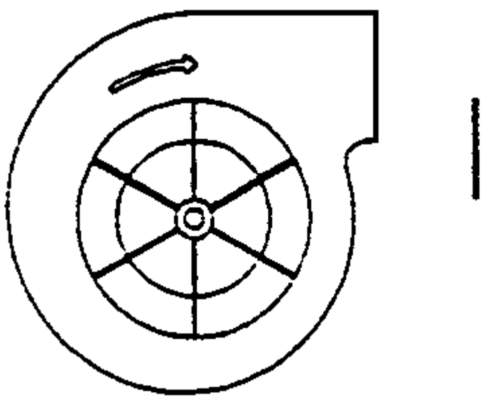
- Blades are curved forward in the direction of rotation
- Large volume at low pressure
- Slow speed
- Small size for a given volume
- Low to medium efficiency
- Must be properly applied to avoid unstable operation
- Clean air and high temperature applications





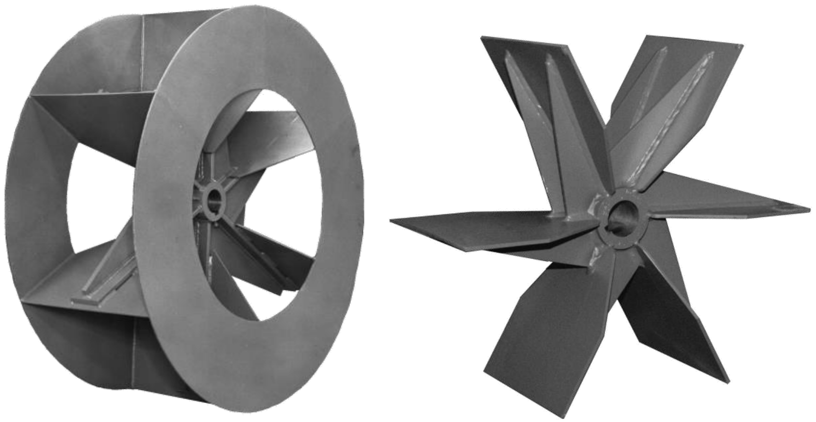
Radial Blade

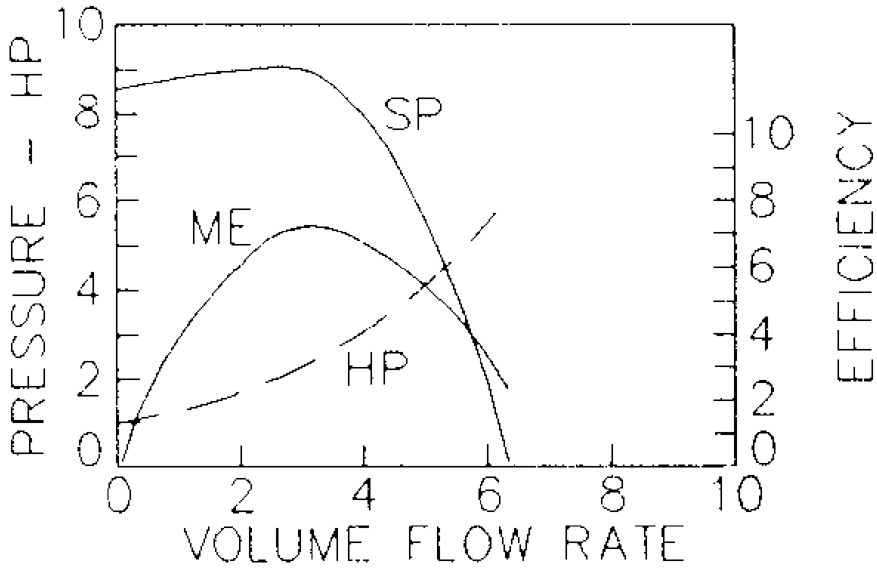
- The blades are “radial’ to the fan shaft
- Generally the least efficient of the centrifugal fans
- For material handling and moderate to high pressure industrial applications



Radial Blade

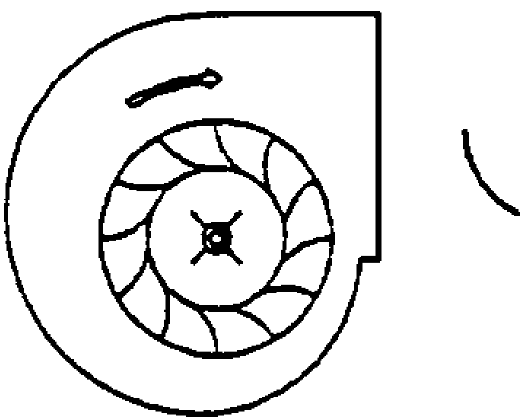
- Low volume at high pressure
- Large wheel diameter for a given volume- higher cost
- Material handling, self cleaning
- Medium efficiency
- Easy to maintain
- Rising HP characteristic
- Suitable for dirty airstream, high pressure, high temperature and corrosive applications

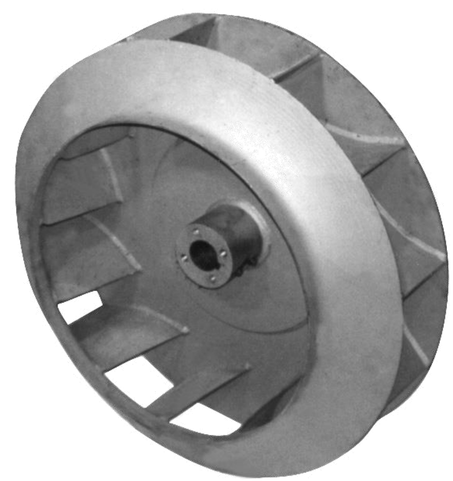




Radial Tip

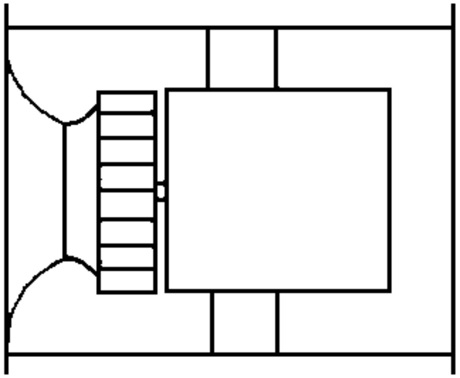
- The blades are radial to the fan shaft at the outer extremity of the impeller, but gradually slope towards the direction of wheel rotation
- More efficient than the radial blade
- Designed to wear resistance in mildly erosive air streams





Inline Centrifugal Fan

- Cylindrical housing is similar to a vaneaxial fan
- Wheel is generally an airfoil or backward inclined type
- Housing does not fit close to outer diameter of wheel
- For low and medium pressure HVAC systems or industrial applications when an inline housing is geometrically more convenient than a centrifugal configuration

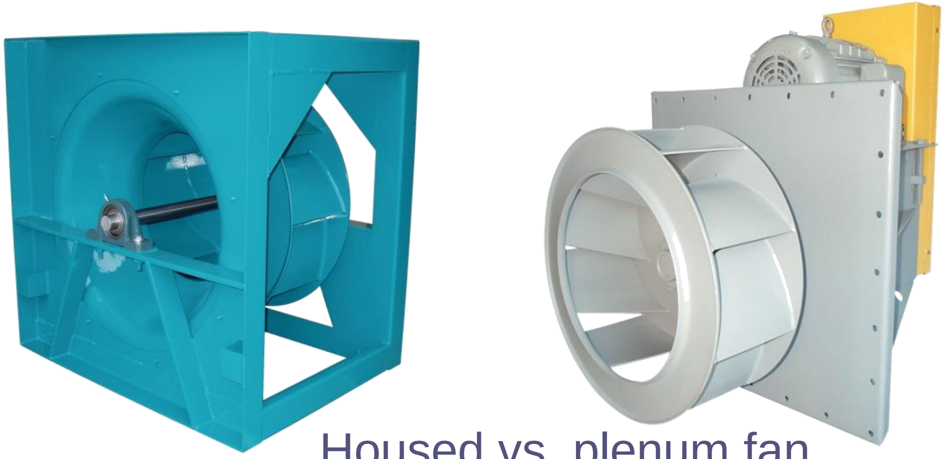


Mixed Flow Fan

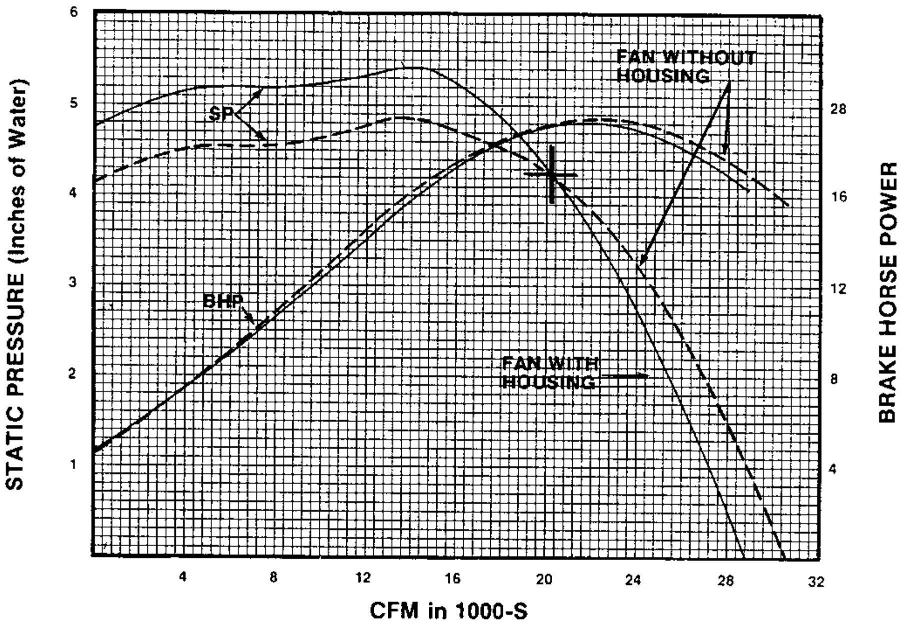
- Cylindrical housing is similar to a centrifugal inline fan
- High volume advantages of axial fans
- Low sound, high efficiency advantages of tubular centrifugal fans

Plenum/Plug Fan

- Offers tremendous flexibility for inlet and discharge in a AHU application
- Works better than a housed centrifugal for high flows and low SP
- Wall clearance rules must be followed to avoid significant system effect losses



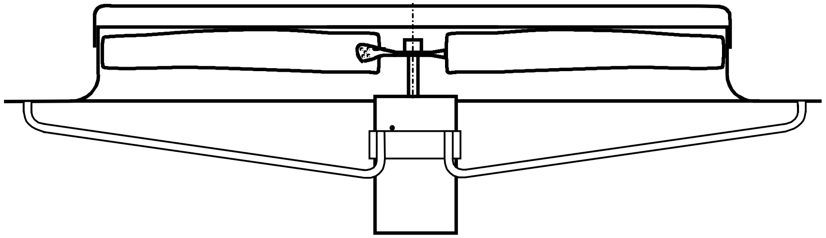
Housed vs. plenum fan

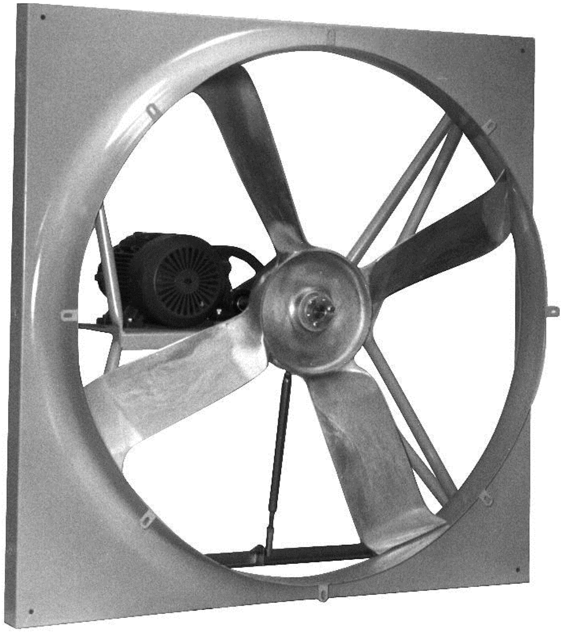


Twin City Fans & Blowers

Propeller or Panel Fan

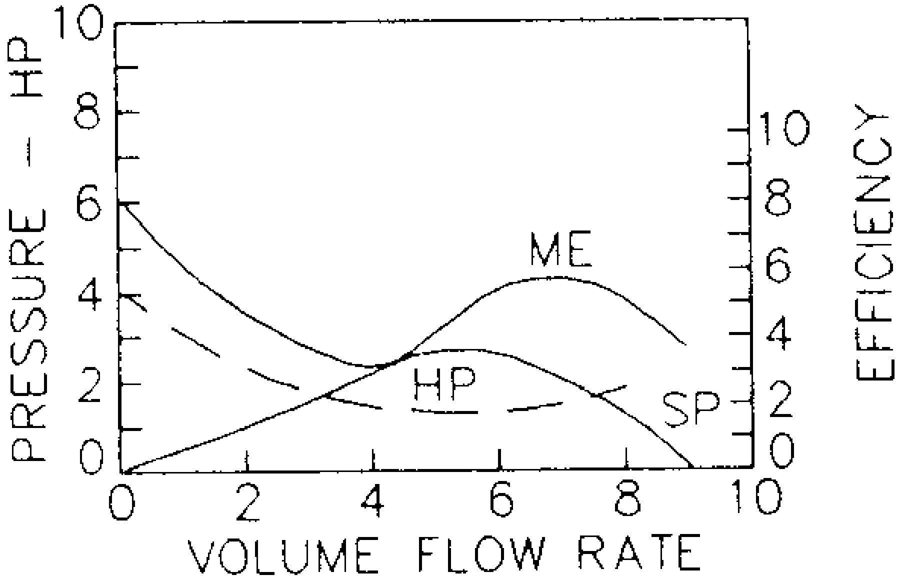
- One of the most basic fan designs
- For low pressure, high volume applications
- Designed for ventilation through a wall
- Also available in ring fan design

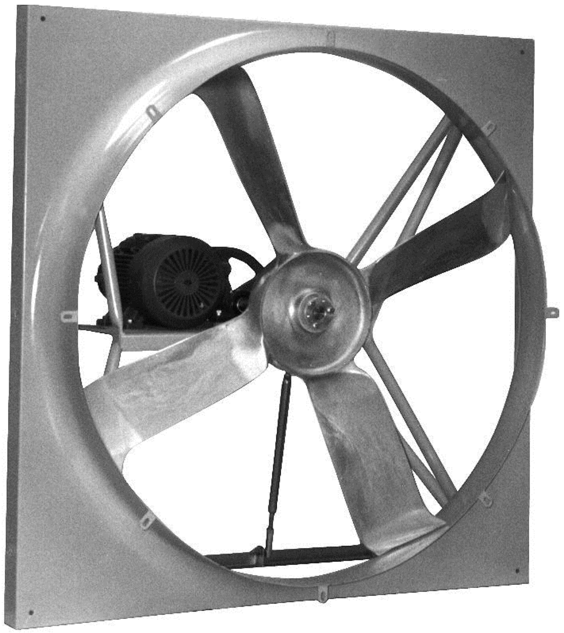




Propeller or Panel Fan

- Maximum efficiency is reached near free delivery

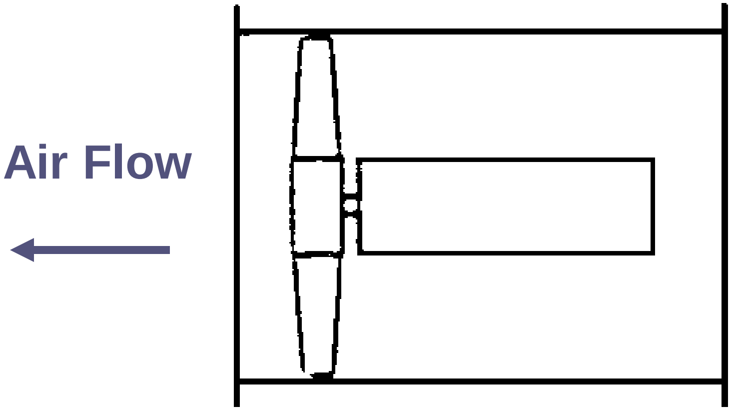




Panel Fan Installation

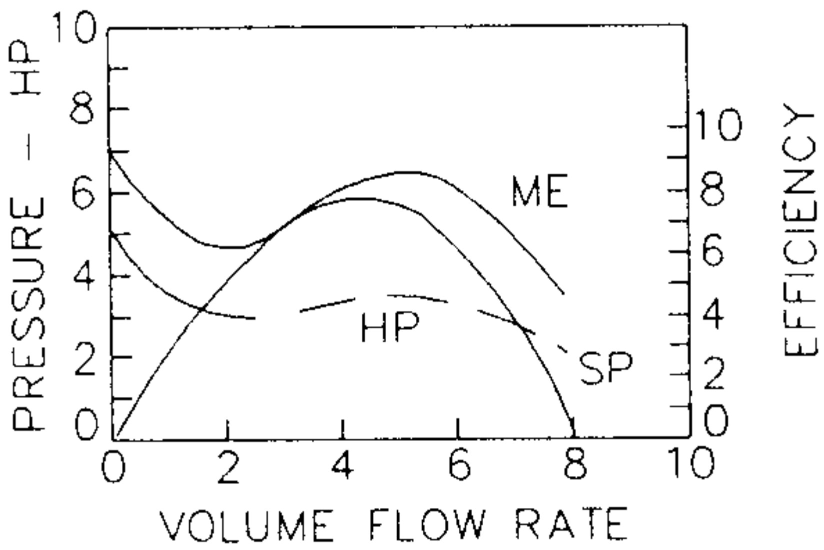
Tubeaxial Fan

- More efficient than the panel fan
- Cylindrical housing fits closely to outside diameter of blade tips
- For low to medium pressure ducted HVAC systems
- Used in low pressure industrial applications



Tubeaxial Fan

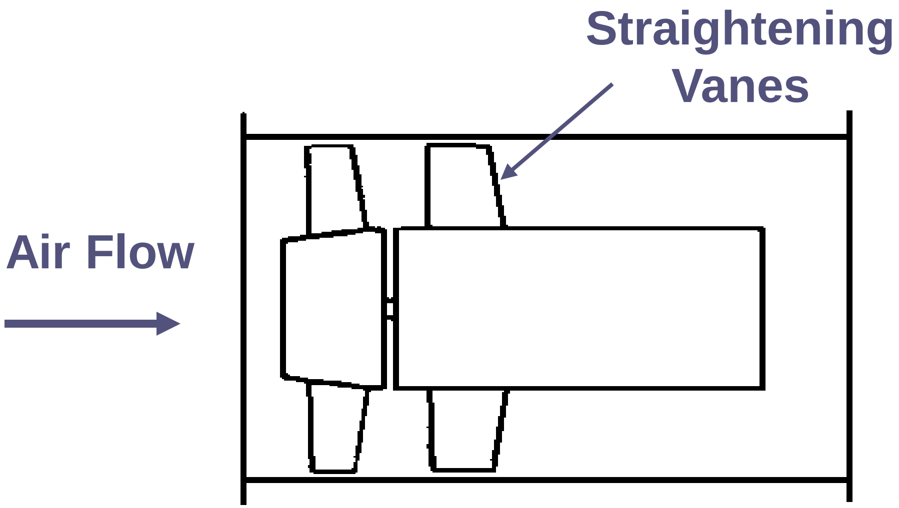
- Performance curve sometimes includes a dip to the left of peak pressure which should be avoided

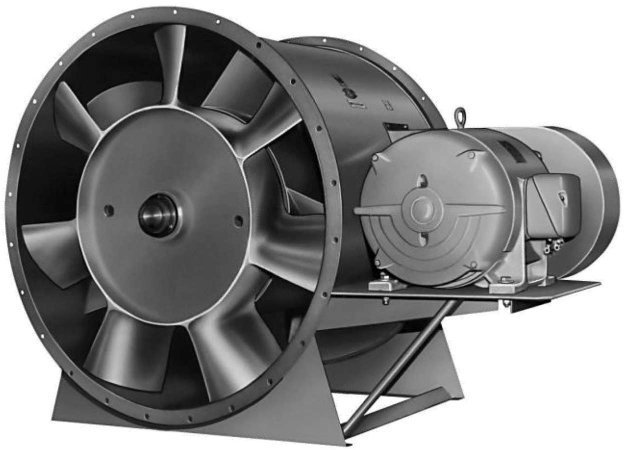


Tubeaxial Fan – Spray Booth Application

Vaneaxial Fan

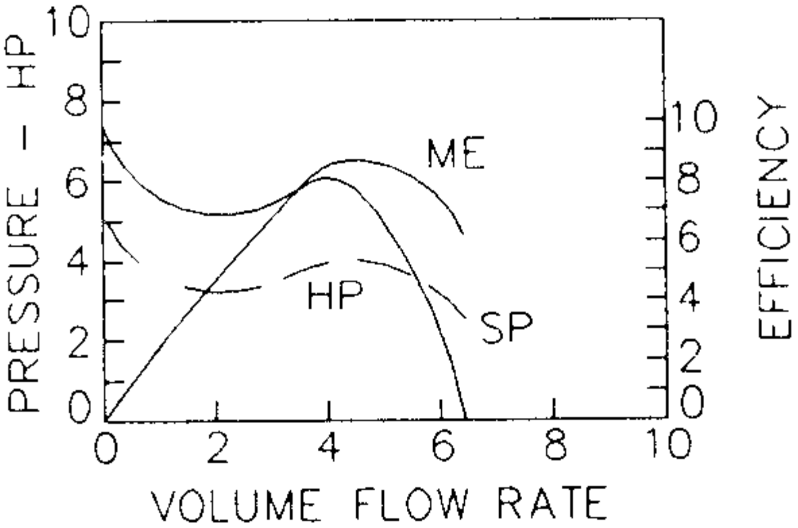
- Highest efficiency axial fan
- Cylindrical housing fits closely to outside diameter of blade tips
- The straightening vanes allow for greater efficiency and pressure capabilities
- For medium to high pressure HVAC systems

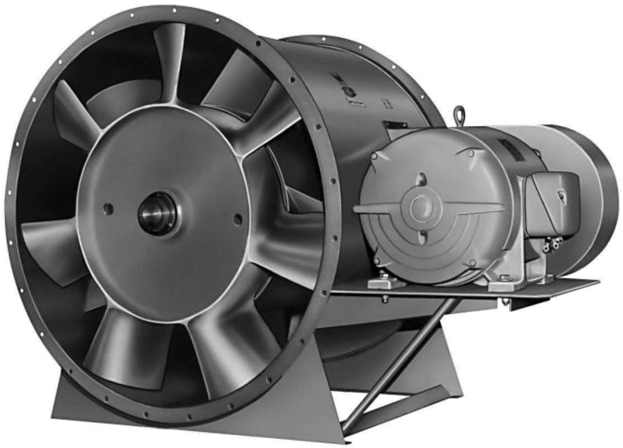




Vaneaxial Fan

- More compact than centrifugal fans of same duty
- Aerodynamic stall causes the performance curve to dip to the left of peak pressure which should be avoided





Vaneaxial Fan Installation

Power Roof Ventilators

- Roof mounted exhaust ventilators. Available in centrifugal or axial wheel designs.
- Available in upblast damper design to discharge air away from the building
- For low pressure exhaust systems of all building types

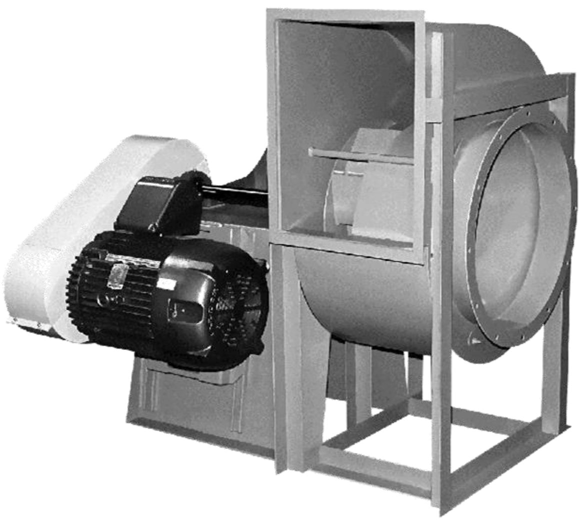


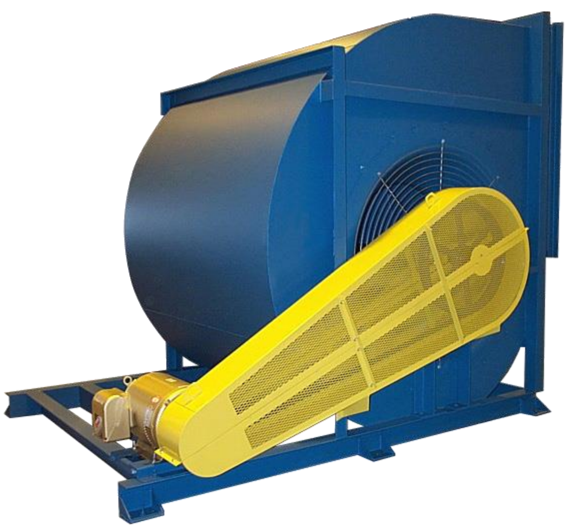
Axial Roof Ventilator

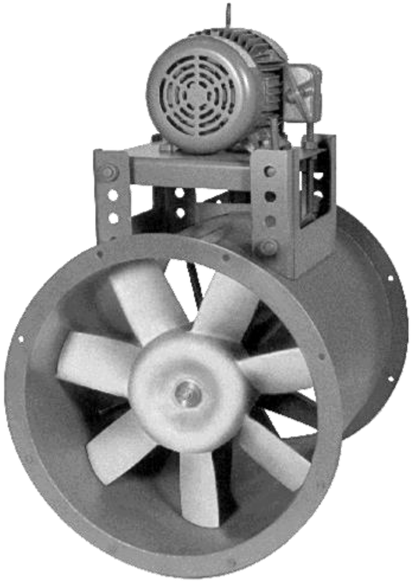
Centrifugal Power Roof Ventilator

Fan Construction

- Drive Arrangements
- Fan Rotation and Discharge
- Fan Class of Construction
- Spark Resistant Construction
- Special Coatings and Materials

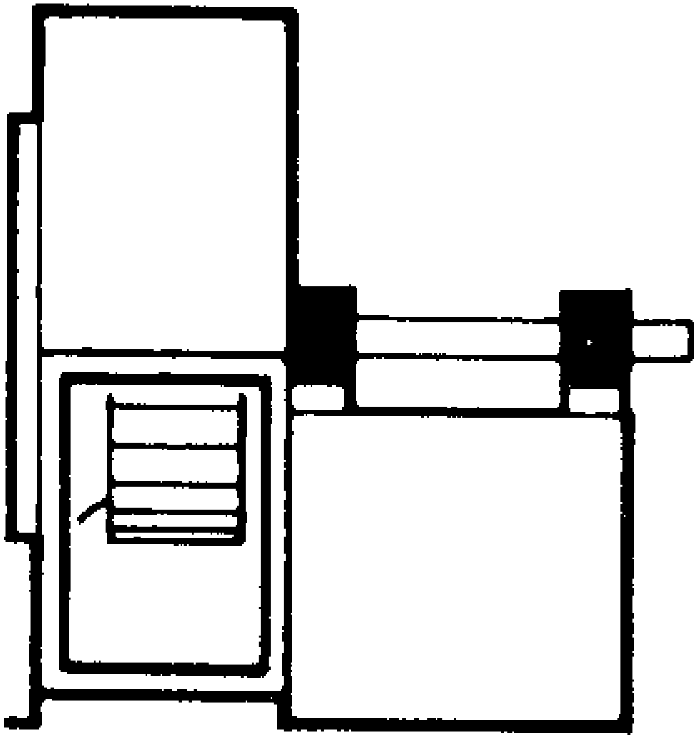






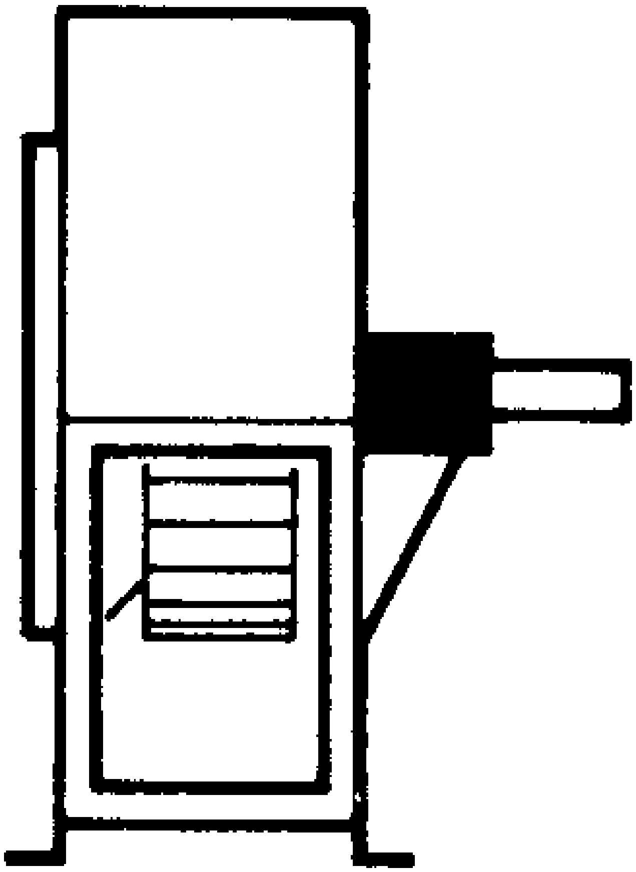
Drive Arrangements For Centrifugal Fans

- Arrangement 1 SWSI
  - For belt drive (or direct) connection
  - Impeller overhung
  - Two bearings on base
  - Motor mounted beside fan, typically on a common base



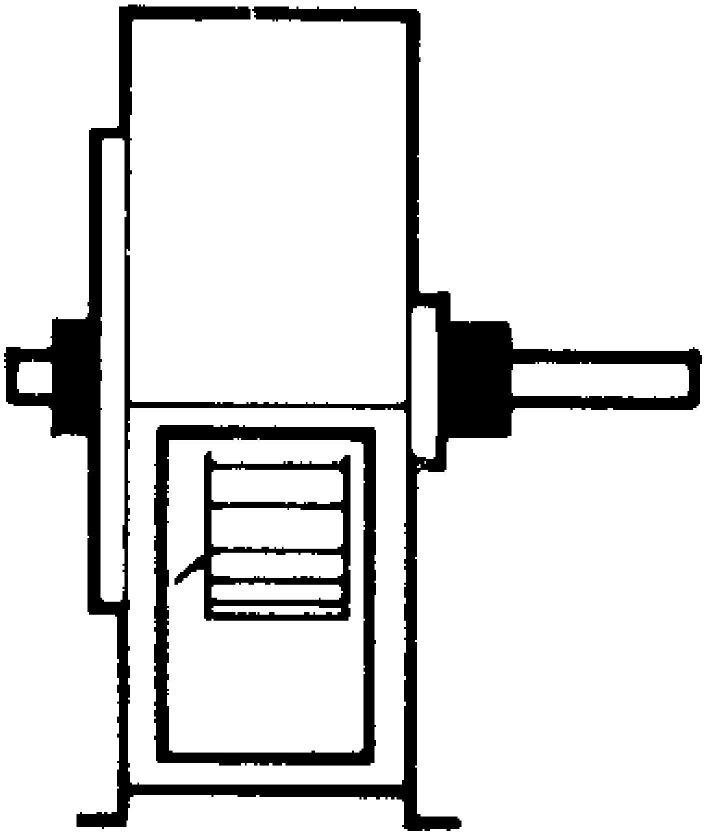
Drive Arrangements For Centrifugal Fans

- Arrangement 2 SWSI
  - For belt drive or direct drive connection
  - Impeller overhung
  - Bearings in bracket supported by fan housing
  - Rarely used today



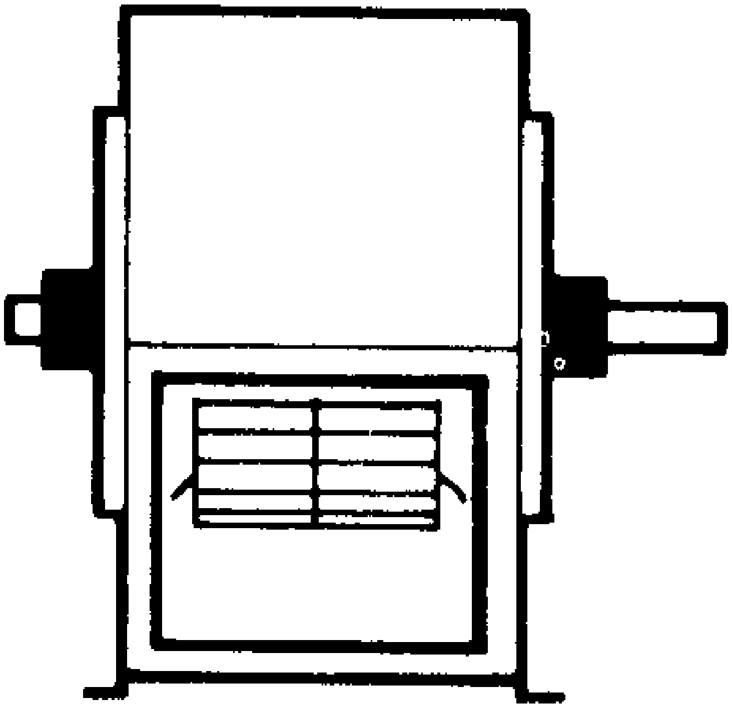
Drive Arrangements For Centrifugal Fans

- Arrangement 3 SWSI
  - For belt drive (or direct) connection
  - One bearing on each side and supported by fan housing
  - Motor mounted beside fan, typically on a common base



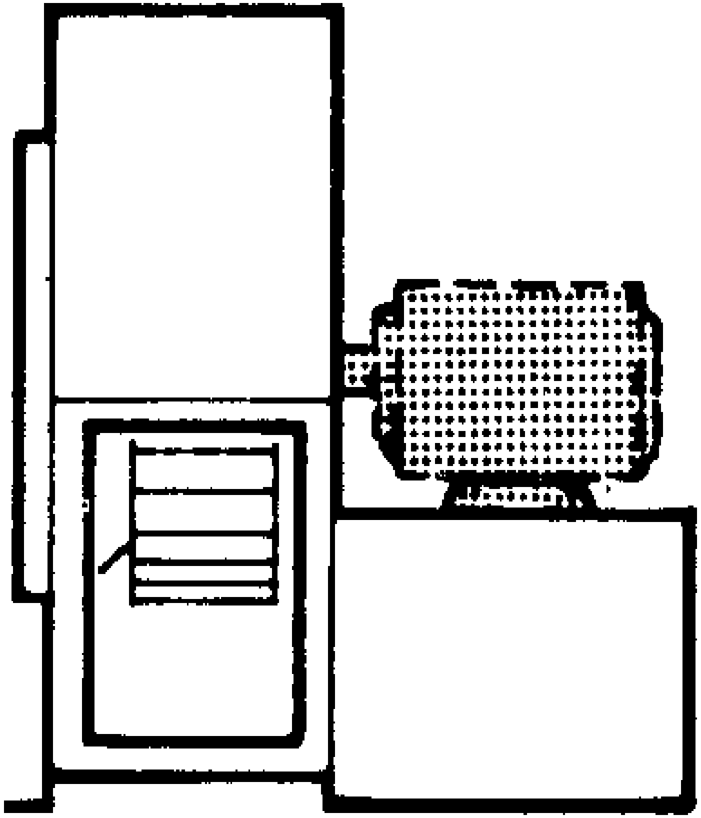
Drive Arrangements For Centrifugal Fans

- Arrangement 3 DWDI
  - For belt drive (or direct) connection
  - One bearing on each side and supported by fan housing
  - Motor mounted beside fan, typically on a common base



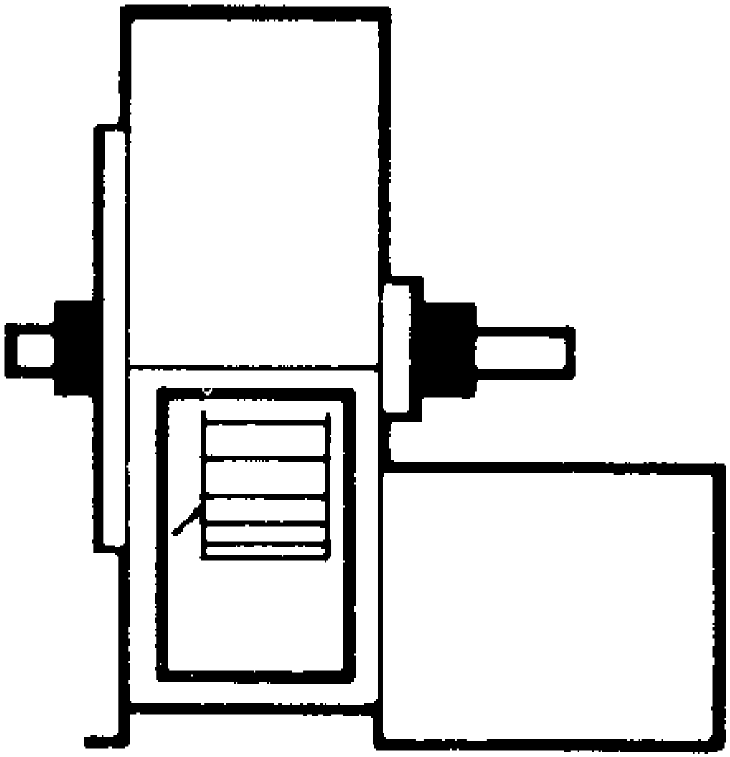
Drive Arrangements For Centrifugal Fans

- Arrangement 4 SWSI
  - For direct drive connection
  - Impeller overhung on prime mover shaft
  - No bearings on fan
  - Motor base mounted or integrally directly connected



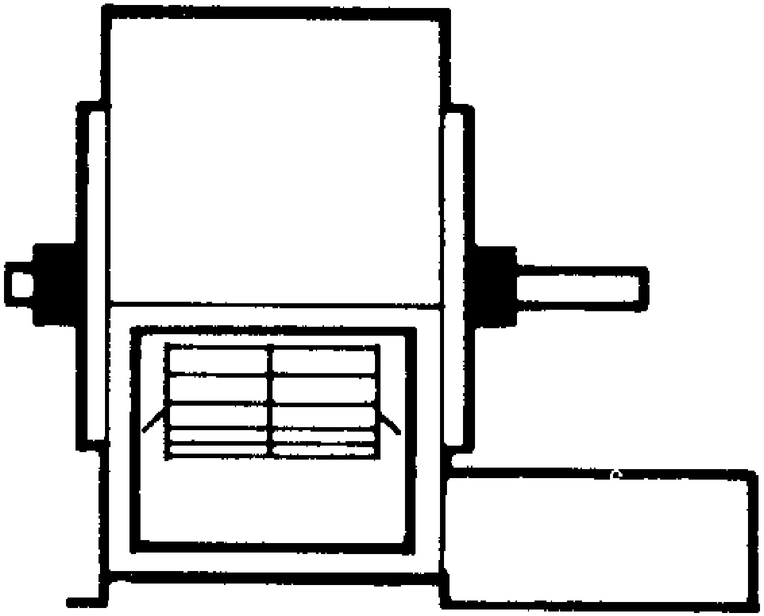
Drive Arrangements For Centrifugal Fans

- Arrangement 7 SWSI
  - For direct drive connection
  - Arrangement 3 plus base for motor
  - Motor coupled to fan shaft



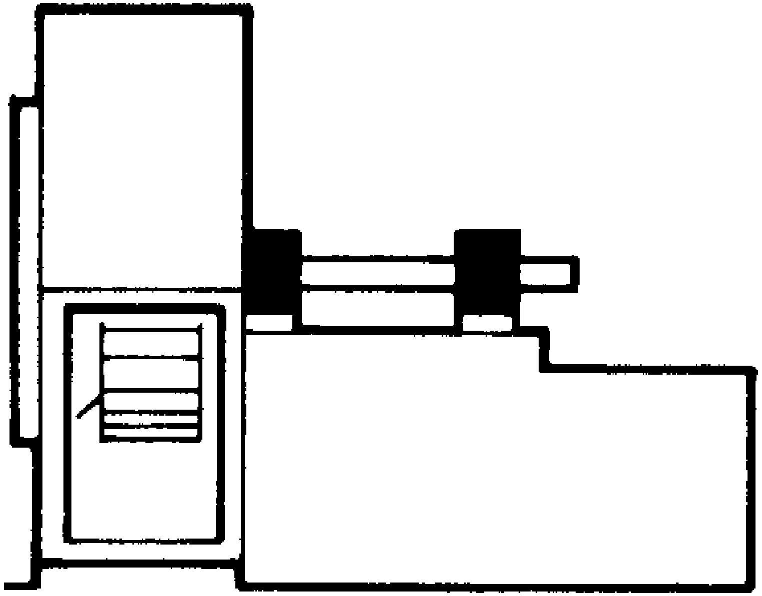
Drive Arrangements For Centrifugal Fans

- Arrangement 7 DWDI
  - For direct drive connection
  - Arrangement 3 plus base for motor
  - Motor coupled to fan shaft



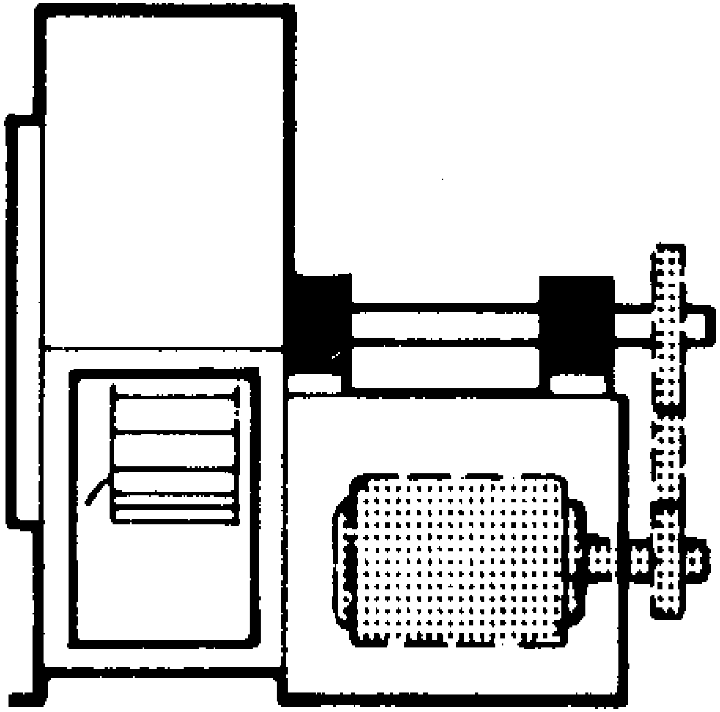
Drive Arrangements For Centrifugal Fans

- Arrangement 8 SWSI
  - For direct drive connection
  - Arrangement 1 plus extended base for motor
  - Motor coupled to fan shaft



Drive Arrangements For Centrifugal Fans

- Arrangement 9 SWSI
  - For belt drive
  - Impeller overhung
  - Two bearings with motor mounted outside base



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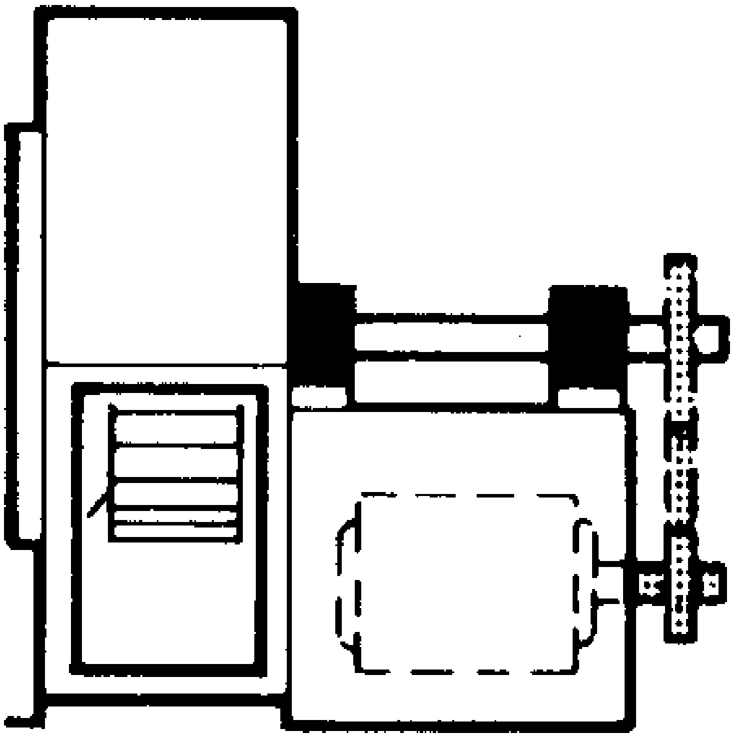
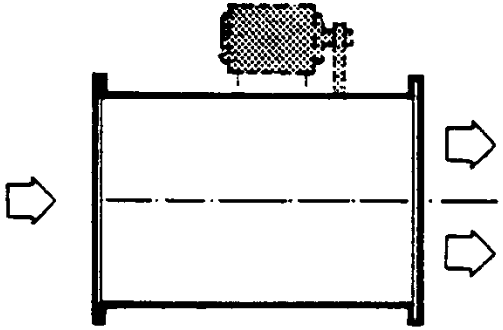
Drive Arrangements For Centrifugal Fans

- Arrangement 10 SWSI
  - For belt drive
  - Impeller overhung
  - Two bearings with motor mounted inside base

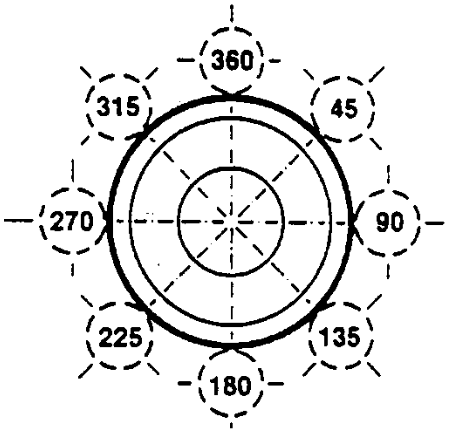


Drive Arrangements for Inline Fans

- Rotation of fans is determined by viewing the fan outlet end
- Specify horizontal or vertical mounting
- Fans can be supplied with support legs for horizontal floor mounting or horizontal clips for ceiling mounting. Vertical mounting clips are also available.
- Arrangement 9 belt drive motor positions



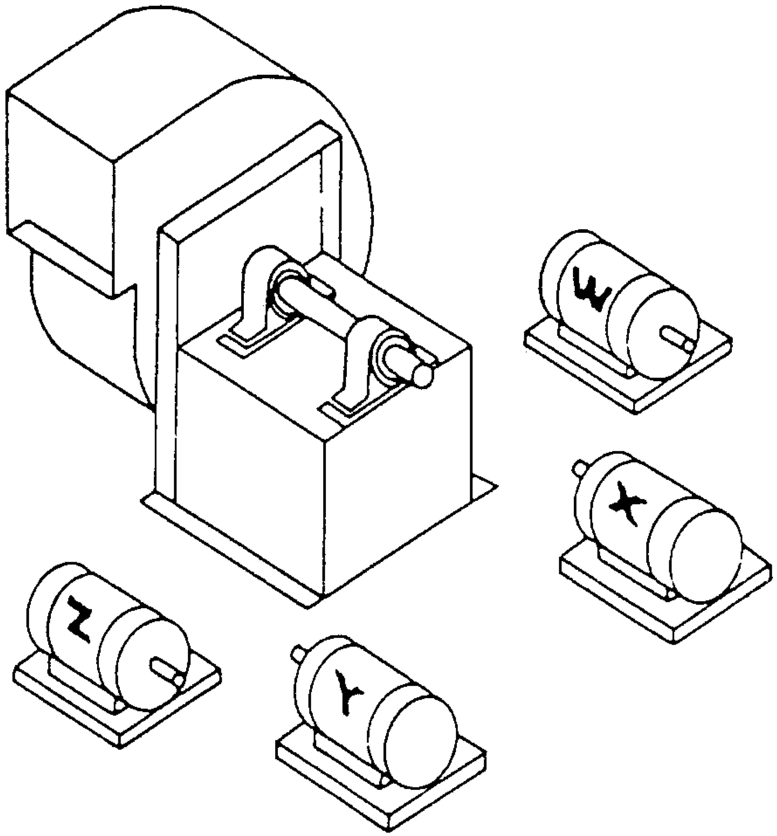
Motor Shown in Position 360



View Facing Outlet

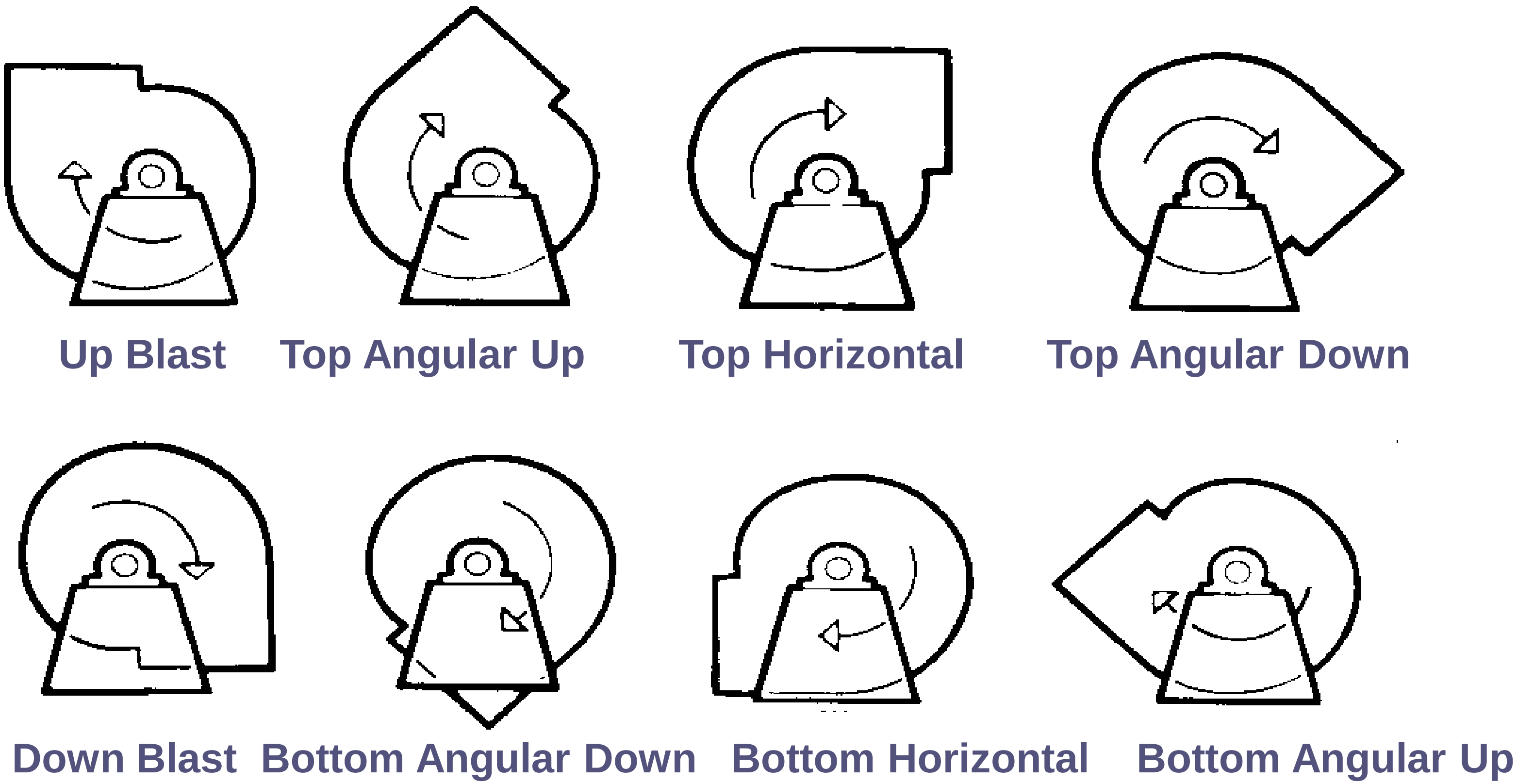
Motor Positions For Belt Drive Centrifugal Fans

- Location of motor is determined by facing the drive side of fan and designating the motor positions by letters W, X, Y, or Z as the case may be.



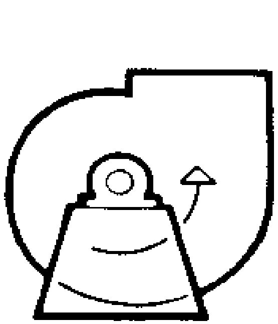
Fan Rotation & Discharge Positions

- Clockwise rotation
  - as viewed from drive end

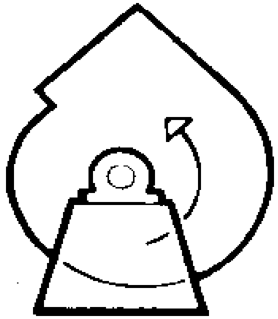


Fan Rotation & Discharge Positions

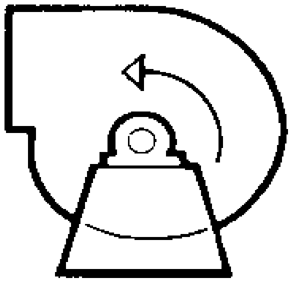
- Counter clockwise rotation
  - viewed from drive end



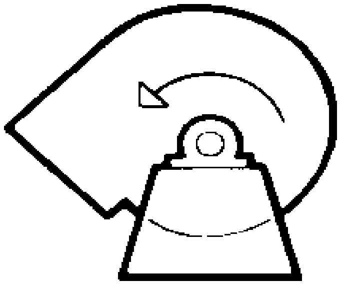
Up Blast



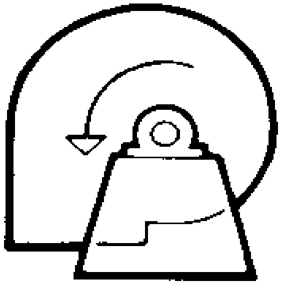
Top Angular Up



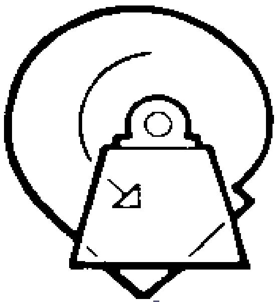
Top Horizontal



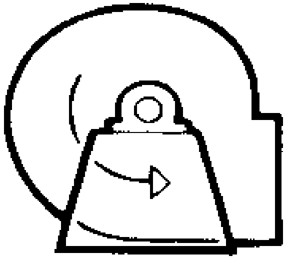
Top Angular Down



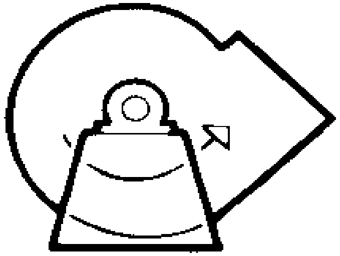
Down Blast



Bottom Angular Down



Bottom Horizontal

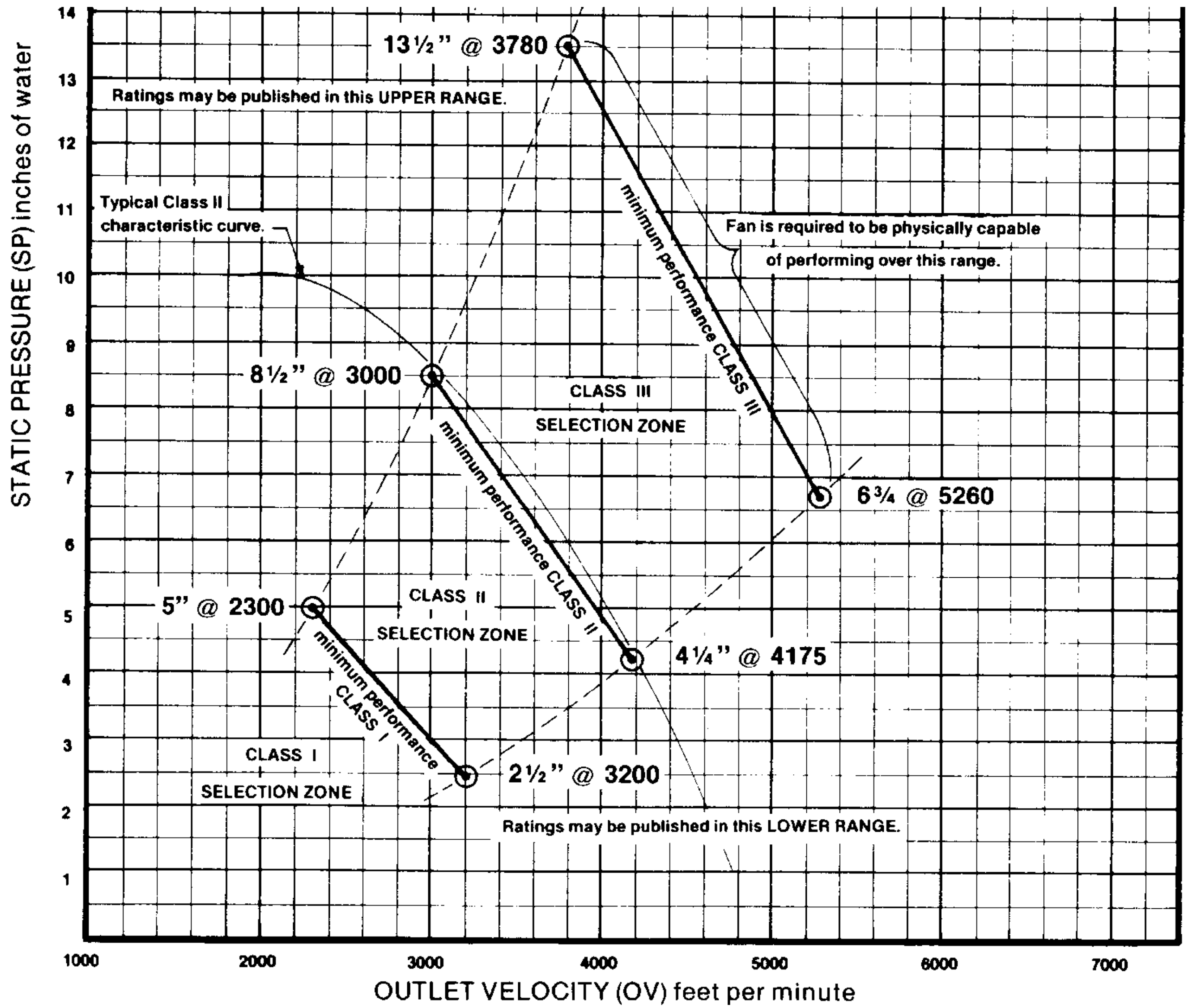


Bottom Angular Up

Fan Class of Construction

- AMCA designates minimum performance requirements for certain types of fans
- Construction standards are set based on pressure and outlet velocity
- Fan manufacturers use a variety of construction nomenclature
- In addition to performance limitations, fans have structural limitations

Centrifugal Fan Class Operating Limits



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Spark Resistant Construction

- Special construction used for applications where spark may ignite explosion
  - flammable or explosive gas or dust in airstream
- AMCA Standard 99-0401-86 has guidelines for spark resistant construction
  - Type A
  - Type B
  - Type C

Spark Resistant Construction - Type A

- All parts of the fan in contact with the air or gas being handled shall be made of nonferrous material
- Steps must also be taken to assure that the impeller, bearings, and shaft are adequately attached and/or restrained to prevent a lateral or axial shift in these components

Spark Resistant Construction - Type B

- The fan shall have a nonferrous impeller and nonferrous ring about the opening though which the shaft passes
- Ferrous hubs, shafts, and hardware are allowed provided construction is such that a shift of impeller or shaft will not permit two ferrous parts of the fan to rub or strike
- Steps must also be taken to assure that the impeller, bearings, and shaft are adequately attached and/or restrained to prevent a lateral or axial shift in these components

Spark Resistant Construction - Type C

- The fan shall be so constructed that a shift of the impeller or shaft will not permit two ferrous parts of the fan to rub or strike

Why Special Materials are Used

- Corrosion resistance
- High temperature
- Spark resistance
- Abrasion and erosion resistance

Why Coatings Are Used

- Corrosion resistance
- Make fan easier to clean
- Aesthetics
- Safety (color marking)

Coating Selection

From Engineering Data Sheet ED-400

Table 4. Corrosion-Resistant Guide to Generic Coatings

CORROSIVE	NO STEEL BLASTING						STEEL BLASTING				
	ASPHALT-UM	VINYL	ZINC	EPOXY	AIR DRIED PHENOLIC	SYNTHETIC RESIN	HEAVY VINYL	EPOXY	BAKED PHENOLIC	PHENOLIC EPOXY	HI-BAKED EPOXY
NUMBER OF COATS	**2**	**2**	**2**	**1**	**4**	**3**	**5**	**2**	**2**	**2**	**2**
ACIDS											
ACETIC	F	F	U	G	G	E	G	G	E	E	E
BORIC	E	G	E	G	G	E	E	E	E	E	E
CARBOLIC	F	U	U	G	G	U	U	G	E	E	E
CARBONIC	F	G	E	E	G	E	E	E	E	E	E
CHROMIC	F	G	U	F	U	G	G	U	F	U	G
CITRIC	G	G	U	G	G	G	E	G	E	E	E
FLUOROBIC	X	G	U	X	G	X	E	X	X	X	X
FORMIC	F	G	X	G	E	G	E	E	E	E	E
HYDROBROMIC	X	X	U	X	U	G	E	X	U	X	U
HYDROCHLORIC	G	G	U	G	G	E	E	G	E	G	E
HYDROFLOURIC	F	F	X	G	U	U	F	G	U	E	E
HYDROCHLOROUS	F	X	X	F	X	E	F	F	F	G	G
LACTIC	F	G	U	G	E	E	G	E	E	E	E

Motor Characteristics

- Horsepower
- Service Factor (Typically 15% or 1.15 SF)
- Frame Size (T-Frame, U-Frame)
- Speed (RPM - Rotations Per Minute)

RPM - 60 Hertz

Synchronous RPM	Actual RPM	# of Poles
3600	3450	2
1800	1750	4
1200	1160	6
900	880	8

RPM - 50 Hertz

Synchronous RPM	Actual RPM	# of Poles
3000	2900	2
1500	1460	4
1000	970	6
750	720	8

Motor Characteristics

- Enclosure:
  - Open Drip Proof (ODP)
  - Totally Enclosed (TEFC, TEAO)
  - Severe Duty (Mill & Chem., Hostile Duty, Dirty Duty...)
  - Explosion Proof
    - Division I = Explosive agent present under normal operating conditions
    - Division II = Explosive agent only present under abnormal operating conditions
    - Class – Defines types of hazardous materials (gases/dusts/fibers)
    - Group – Defines the relative degree of hazard for each type of hazardous material

Motor Characteristics – Exp. Motors

Class	Group	Atmosphere	Notes
I (Gases)	A	Acetylene	Motor Not Available
I (Gases)	B	Hydrogen, Manufactured Gas	Motor Not Available
I (Gases)	C	Ethylether Vapor	Motor Available
I (Gases)	D	Gasoline, Petroleum, Naptha, Alcohol's, Acetone, Lacquer Solvent, Natural Gas	Motor Available
II (Dust)	E	Metal Dust	Motor Available
II (Dust)	F	Carbon Black, Coal or Coke Dust	Motor Available
II (Dust)	G	Grain Dust	Motor Available

Motor Characteristics

- Phase:
  - Single (Normally Available up to 10 HP)
  - Three
- Voltage-1 Phase:
  - 115, 230 standard in US & Canada
  - 110, 220 International (50 HZ)
- Voltage-3 Phase:
  - 200, 208, 230,460 standard in US
  - 575 in Canada
  - 190, 380, 415, 440 International (50 HZ)

V-Belt Drives

- Economical Means of Transferring Power from Motor Shaft to Fan Shaft
  - Motor Sheave – Fixed or Adjustable Pitch
  - Fan Sheave
  - Belts

V-Belt Drive: Advantages and Disadvantages

Advantages

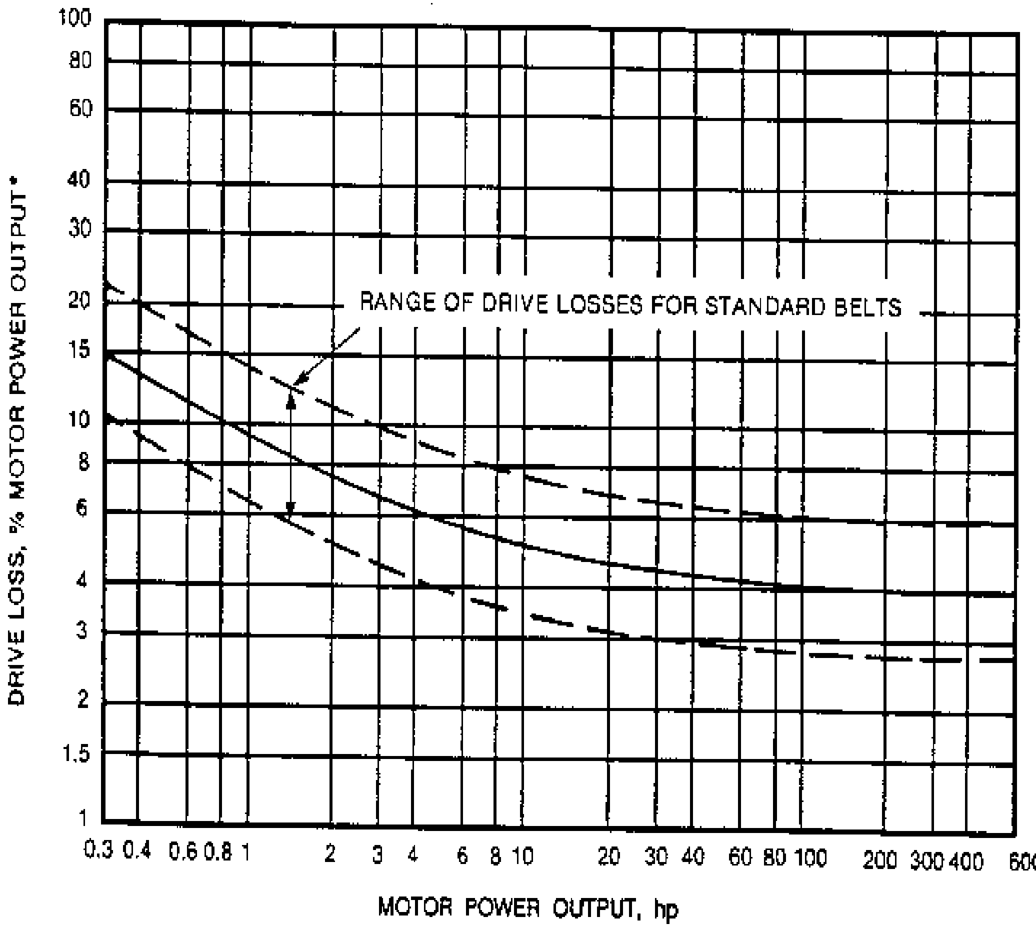
- Easy to change fan speeds and performance
- Lower initial cost than direct drive

Disadvantages

- Requires more maintenance
- More difficult to guard
- Belts create dust (clean room problem)
- Tougher to achieve tight balance
- Drive losses due to belt slippage

Estimated Belt Drive Loss

- Higher belt speeds tend to have higher losses than lower belt speeds at the same horsepower
- Drive losses are based on the conventional v-belt which has been the “work horse” of the drive industry for several decades
- Typically, an additional 5% to 7% should be added to fan BHP for sizing motors



Direct Drive: Advantages and Disadvantages

Advantages

- More compact
- Less maintenance
- No drive loss
- Easier to balance to low vibration levels

Disadvantages

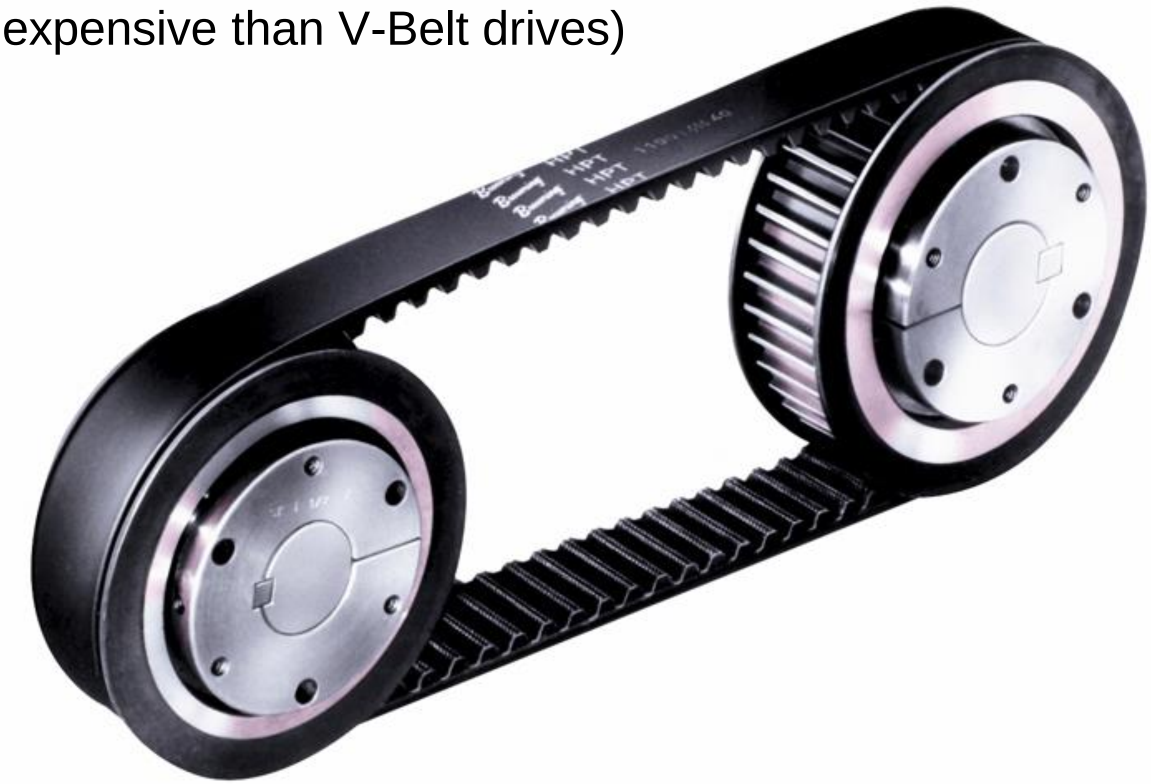
- More difficult to make fan selections
- May require modified wheel
- Couplings can be difficult to align on Arrangement 7 or 8 fans

Belt Drive – Final Comments

- TCF does not recommend adjustable sheaves on fans with motors over 10 HP
  - Cost – Adjustable sheaves are 2-3 times more expensive than fixed sheaves.
  - Adjustable sheaves use set screws to lock in pitch diameters and set screws can vibrate loose.
  - Belt life is shorter on adjustable pitch drives (belt rides higher or lower in sheave).
- TCF does not recommend two groove drives on fans with fractional HP motors.
  - Fan motor may not be able to start fan because of the two grooves.

Belt Drive – Final Comments

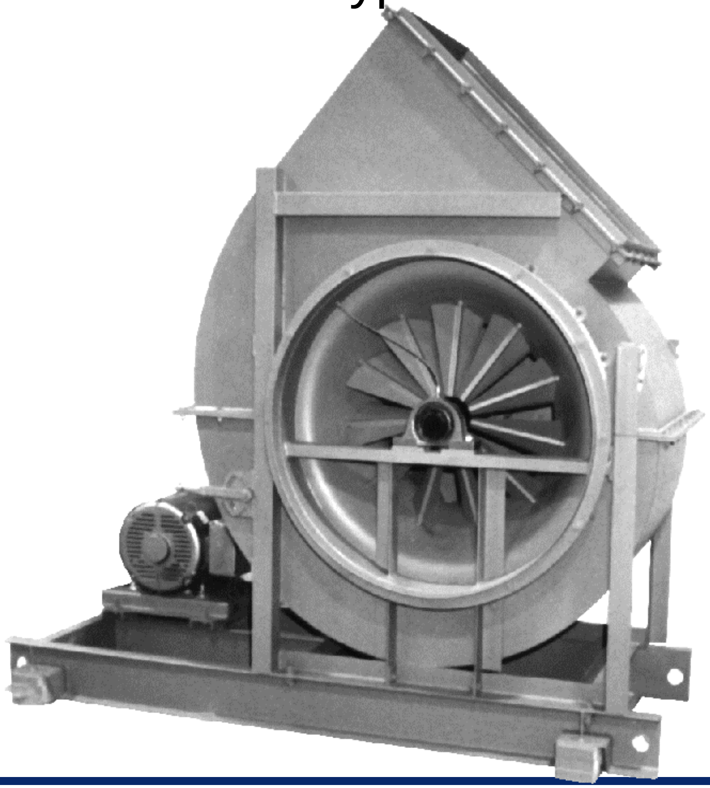
- Timing Belt Drives
  - TCF does not recommend the use of timing belt drives on fans.
    - Noise (13 DBA louder than V-Belt drives)
    - Alignment is critical
    - No slip characteristic is hard on motors
    - Increased vibration
    - Cost (2-3 times more expensive than V-Belt drives)



Fans & Blowers
Twin City

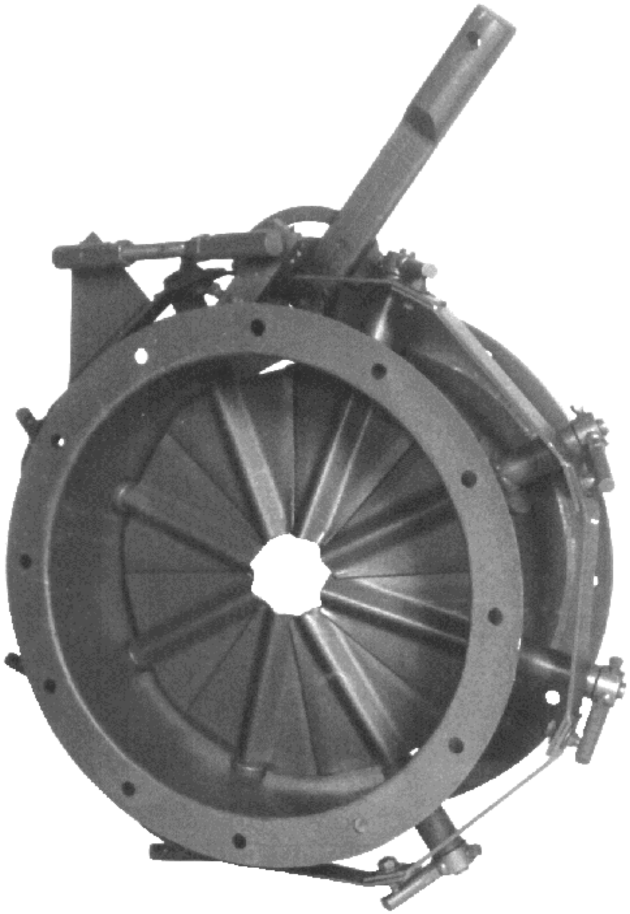
Nested Inlet Vanes

- Mechanical Volume Control Device
- Nested inlet vanes are built into the fan inlet cone
  - Saves space
  - Less expensive than external type

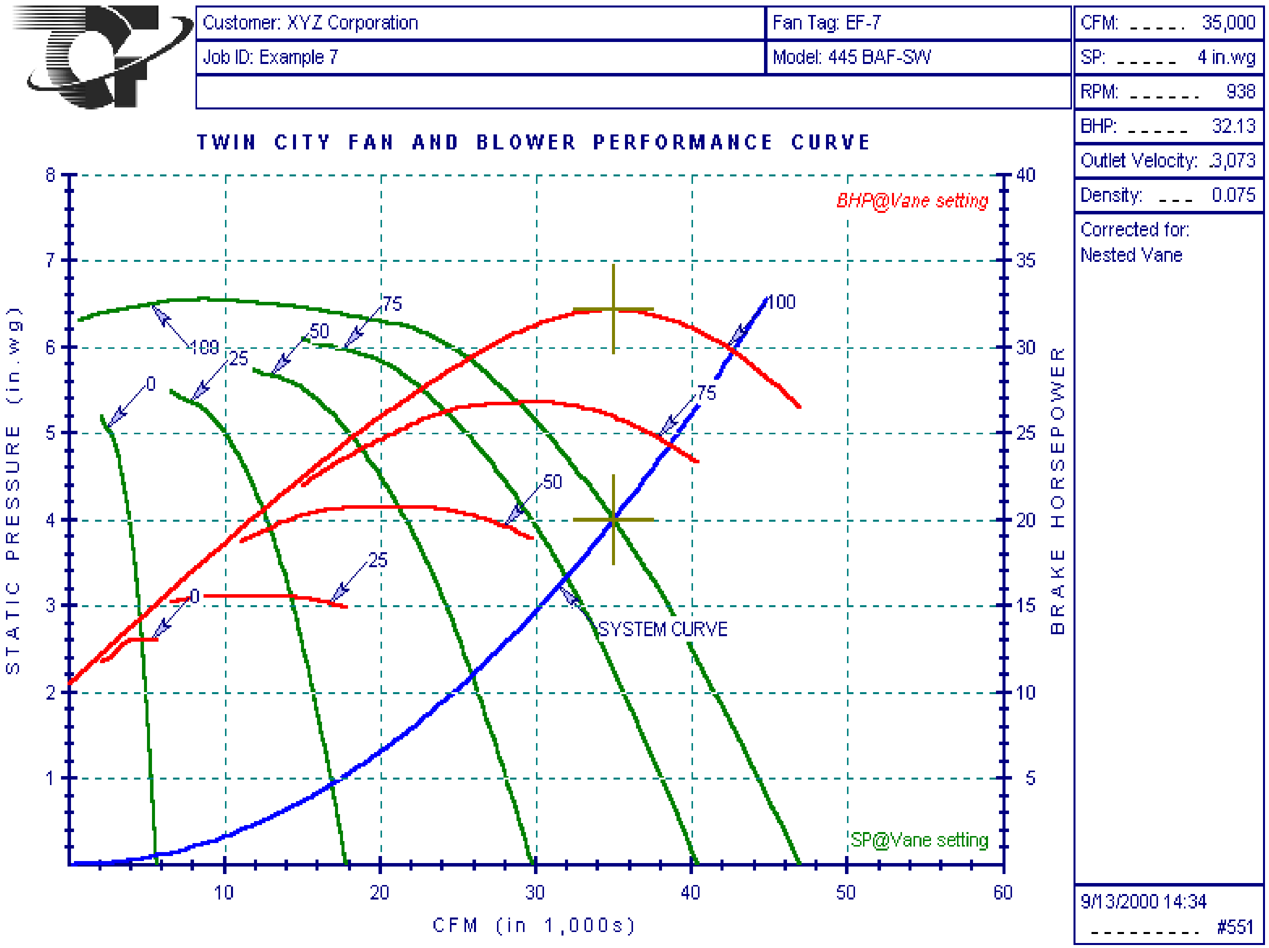


External Inlet Vanes

- External inlet vanes are bolted to the inlet flange of the fan
- Use of external vanes should be considered for handling hostile environments since operating linkages are shielded from the airstream
- External inlet vanes are available for high temperature construction



Inlet Vane Curves

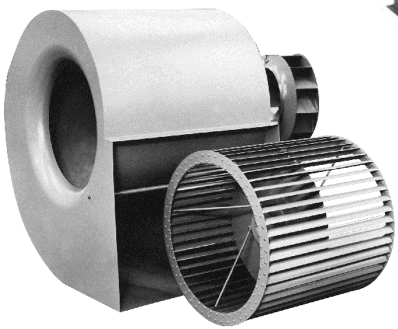


INLET VANE POSITION

% Open	BHP
100	32.13
75	27.00
50	21.00
25	16.00

Selecting the Right Fan

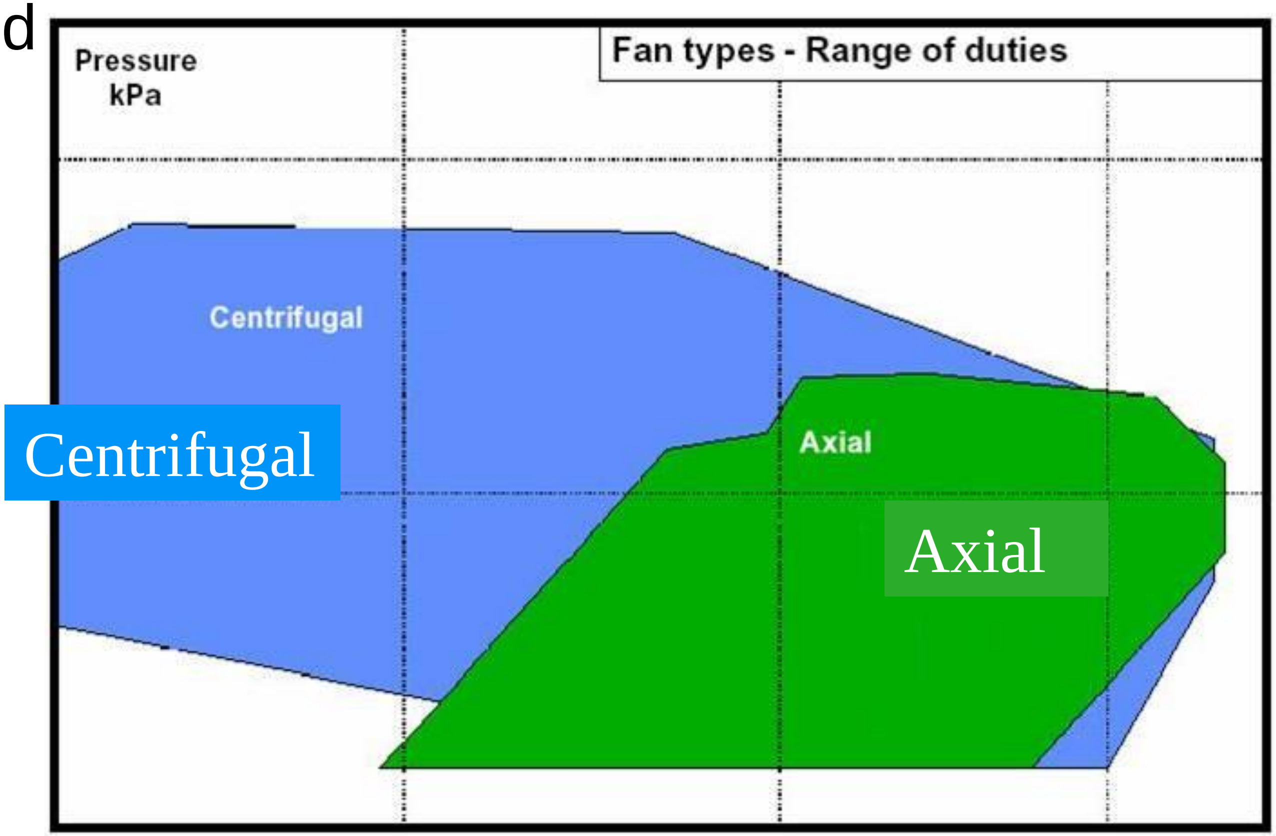
- Selecting the right fan involves considering and prioritizing many variables
  - Application
  - Performance (flow and pressure)
  - First Cost of Fan
  - Operating Costs
  - Life, Durability & Reliability
  - Space Requirements
  - Simplicity of Installation
  - High Temperatures and Severe Environments
  - Variable Volume Requirements
  - Sound Output
  - Etc...



Flow and Pressure

- The required flow and pressure may control the style of fan used

Pressure



Flow

Fans & Blowers
Twin City

First Cost vs. Operating Cost

First Cost Considerations

- First cost should include the installation costs
- Unfortunately, some never look beyond this
- Make sure that all desired features are included when comparing costs

Operating Cost Considerations

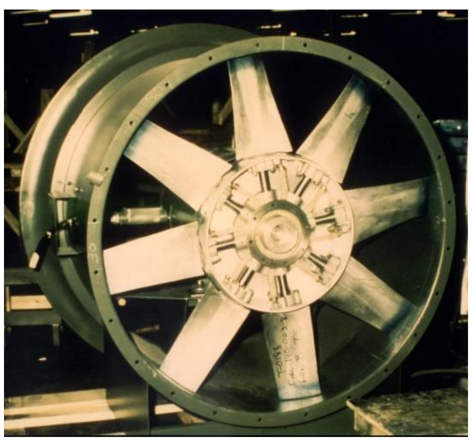
- The ‘BHP’ (brake horsepower) of the fan will identify operating costs
- For variable volume systems, use BHP at part load
- Add losses for v-belt drives, inverters (VFD’s), and system effect losses

Expected Life, Durability, Reliability

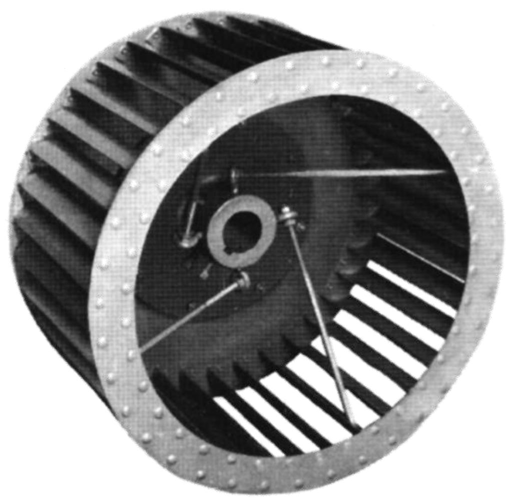
- Difficult to quantify
- Compare materials of construction
- Use higher ‘class’ of construction
- Compare bearing life
- Lower speed operation is often more reliable
- Fans are often customized to improve reliability

Space Requirements

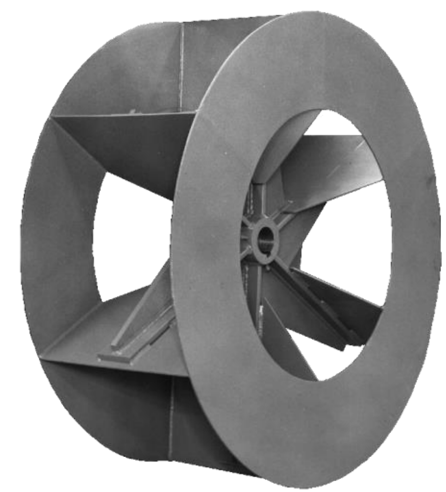
- Axial fans are usually smaller than centrifugal fans
- Forward curve fans are smaller than other centrifugal fans
- Radial bladed fans tend to be the largest fans
- Fan “arrangement” affects space



Axial



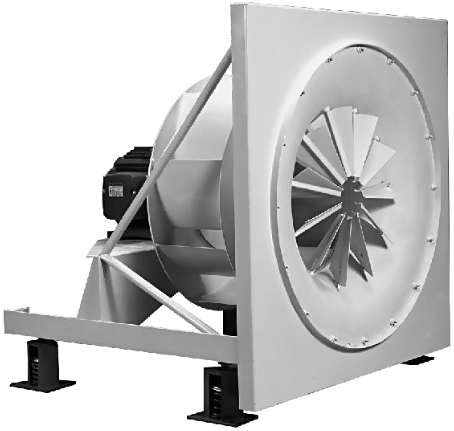
Forward Curved



Radial

Simplicity of Installation

- Fan “arrangements” with motor mounted are easier to install
- Fan discharge position may simplify ductwork
- Use axial fan for straight through flow

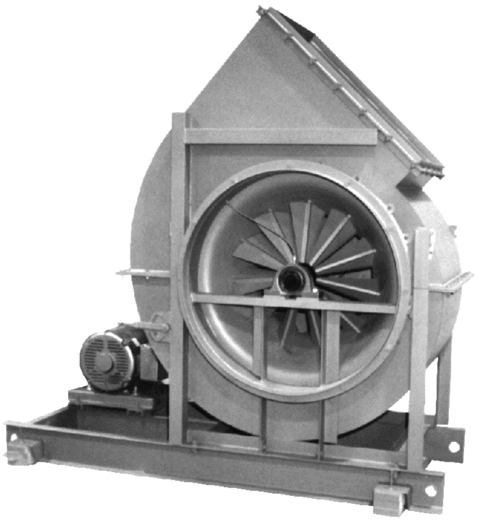


High Temp and Severe Environments

- Bearings, v-belt drives, and motors may need protection and/or cooling
- High temperatures and corrosive environments may require special materials, and or coatings
- Need to know airstream conditions and ambient conditions
- Quantity and type of solids in the airstream can limit usable fan types

Variable Volume Requirements

- Methods of adjusting flow volume will vary with fan types
- The ability to supply a variety of flow-pressure combinations with stable flow affects the fan type and fan size
- Customize fan to optimize for variable volume requirements



Nested Inlet Vane	Parallel Fans
External Inlet Vane	Clutches
VFD	Turbine Drive
Outlet Damper	Adjustable Pitch Axial
2 Speed Motors	Controllable Pitch Axial

Sound Output

- Axial fans generate more noise than centrifugal fans
- Axial fan noise is in higher frequencies, which are easier to attenuate
- Forward curve noise is the most ‘pleasing’ and seldom generates noise problems
- Airfoil bladed centrifugals normally have the lowest sound output

Other Factors Affecting Fan Selection

- Ultra-low vibration requirements
- Low maintenance (fan inaccessible)
- Flow measurement devices
- Maximum (or minimum) outlet velocity
- Present and future performance needs

Thank you