PRODUCT APPLICATION GUIDE

A technical bulletin for engineers, contractors and students in the air movement and control industry.

Fan Applications

There are many different types of fans and many applications in which they can be used. For an application to be successful and work as intended, the fan and system must be compatible both structurally as well as from a performance standpoint.

This section outlines several generic fan applications and the major considerations relating to fan type, rating parameters and fan design. Please use this information as a part of the fan selection process.

Major Application Considerations

All of the previous applications can be reduced to a few generic application characteristics such as clean or dirty air, normal or high temperature, fume or gas control, low or high erosion, etc. The enclosed matrix provides guidance for those elements that should receive special attention during the selection process. These characteristics are not all inclusive, however, they do present a good starting point for a successful application.

Major Considerations Defined

A. Fan Types

1. Propeller fan: Propeller fans may have many different blade shapes and number of blades. They generally have relatively small hubs. They may or may not have a housing. Housings are in the form of a panel with an orifice in it. The panel is mounted in a wall so that air does not re-circulate from the discharge back to the inlet. Pressures are normally less than one inch of static pressure with very high flow rate. These fans are best suited for circulating air, supplying and exhausting clean ambient air from/to large spaces.

2. Centrifugal Airfoil, Backward Inclined, Backward Curved: These fans are the most efficient of the centrifugal designs. Static efficiencies peak at around 80 percent and occur around 60 percent of free delivery. Their performance characteristic curve is stable over a wide range. The fan horsepower curve is non-overloading. The fan design is suitable for all forms of control methods. It is primarily suited for clean air applications but

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non-sticky dust like particles can be handled. Due to stress considerations, this design is best suited for moderate speeds through class III (up to 13.5 inches w.g.) and moderate temperatures through 800° F.

3. **Forward curved centrifugal**: This fan is generally wider with shallow scooped blades making it well suited for handling high flow rates at low pressures. The design is limited primarily to lower speeds and temperatures due to stress levels. Some designs incorporate internal struts for added stiffness during starts and stops. The performance curve is stable from free delivery to peak pressure, but there is a dip to the left of peak pressure. The horsepower curve rises constantly and relatively sharply from shut-off to free delivery. Its efficiency is relatively low but this is not typically critical because most applications are relatively low in horsepower. Control is by dampers, speed change and sometimes by inlet guide vanes.

4. **Vane axial:** These fans are well suited for high flow rates at low to moderate pressures up to six inches of water. There are several blade variations as to shape, numbers and whether they are fixed, adjustable or controllable blade pitch. The fans are characterized with large hubs and straightening vanes. The airflow is straight through, saving space. The performance curve is stable from free delivery to peak pressure, however, there is a stall area just behind peak pressure where it should not be operated. Sound levels have a higher frequency characteristic which makes it easier to attenuate if need be.

5. **Mixed flow inline**: The wheel design is a combination of axial and centrifugal components. It operates most efficiently in the range between a vane axial and a centrifugal satisfying applications for moderate flow rates and moderate pressures. The housing is similar to a vane axial incorporating guide vanes and straight through flow thus saving space. The fan's main advantages are its lower sound levels and high operating efficiencies.

6. **Radial, radial tipped**: These fans have efficiencies in the 60 to 75 percent range and have a higher pressure characteristic than most fans. The horsepower curve rises constantly from shut-off to free delivery. Due to turbulence and the blade shape, these fans can handle contaminants in the air stream. Wheels often incorporate wear protection for longer life. These fans can be modified or designed to accommodate high temperatures.

7. **Paddle wheel**: This design is used primarily for conveying material. It is normally very rugged in design in order to accommodate impact forces and limit fatigue cracks. Shafts and bearings are typically oversized for durability. Density calculations should not only reflect the air but the material passing through the fan for horsepower predictions to be accurate. Efficiencies are relatively low.

8. **Plenum**: This design incorporates an AF, BI, BC wheel without a housing. The primary purpose is to pressurize a compartment or plenum forcing a uniform flow of air downstream from a higher to a lower pressure region. It is less efficient than a housed unit but is well suited for saving space and minimizing ductwork configurations.

9. **Inline fans:** Inline fans may utilize a centrifugal, mixed flow or axial type wheel in a round tube or square shaped housing. When supplied with a centrifugal wheel and guide vanes within the tube, the term "tubular centrifugal" is normally used. When supplied with a mixed flow type wheel, the term "mixed flow" is normally used. When supplied with an axial type wheel without guide vanes, the term "tube axial" is normally used. Inline fans are typically used in space saving applications in which the pressures are relatively low (2-3 inches of static pressure) at moderate flow rates, but can handle pressures up to 8 inches w.g.

B. Ratings

1. **Efficiency**: Efficiency is an important factor considering the relatively high cost of energy. The operating point location on the fan curve must be considered when controls are to be used to modulate the fan over a wide flow range. Various controls must be evaluated for effectiveness and their impact upon fan efficiency at lower flow rates.

2 **Single or parallel operation**: There are many different reasons for using multiple fans in a single system. They may be in series or parallel and one fan will have an impact upon the other fans during control or start-ups or shut downs. Stability is very important and the operating point location on the fan curve must be evaluated during all changes. (Refer to FA/115-02)

3. **Method of control**: When selecting fans it is most important to know the control method and its characteristics ahead of time. The operating point location on the fan curve should be evaluated for each duty cycle as well as sound requirements.

4. **Special air density**: Many applications operate close to the standard density corresponding to 70° F sea level and a specific gravity of one. However changes in altitude, temperature, specific gravity, materials in the air stream and suction pressure can all affect the fan air density which has a great impact upon the fan's performance. (Refer to FA/101-99)

5. **Sound**: Fans make sound as a by-product of handling air. Sound can be minimized by using the right fan type, selecting the operating point near peak efficiency and using a larger fan at a slower speed. Fan location is critical in some applications and should not be located near sensitive office areas, conference rooms, etc. The control method will also have an impact upon the fan noise. (Refer to FA/121-03, FA/122-03, FA/123-03))

6. **Non-surge, stability**: The operating point location on the fan curve determines the fan/system stability. Some fans have stall areas, discontinuities and flat portions of their curves where hunting can occur. The slope of the fan curve is important when applying fan controls.

7. **Capture & Entrainment Velocities**: Fans and systems that convey materials must be sized so that the airstream can pick up or capture the material and then keep it suspended in the airstream (entrainment) so that it will not settle out at some location in the system.

C. Design

1. **Location**: Knowing where a fan is to be located can make or break an application. Different considerations apply whether a fan is indoors, outdoors, mounted on a concrete slab or several stories up in a structure. Fans should not be located near sensitive offices or conference rooms. High speed fans should not be near property lines. Maintenance and the ability to install and/or remove components is important. Proper distances must be maintained between fans and walls, other fans, etc. so that system effects are minimized.

2. **Orientation**: Proper fan orientation and connection to the system are critical factors in applying a fan properly. Connections should not disturb the air entering the fan or additional losses known as system effects will occur. (Refer to FA/119-03)

3. **Vibration**: Vibration is important not only to the life of the fan but to the acceptability of the application. Fans must be installed and mounted upon proper bases that are flat and level. Vibration isolation may be necessary to limit the transmission of vibration and structure-borne noise into a building. Vibration isolation may require flex connections, rubber mats, neoprene isolators, springs, snubbers etc. An isolation base may be required for high speed applications. (Refer to FA/108-00)

4. **Leakage and sealing**: Many applications require contaminants in the airstream to not leak out through connections, shaft openings, accessories or seams in housings. Toxic gasses may require completely air tight construction for safety of personnel. At times, special tests are specified to determine leakage rates.

5. **Spark resistant construction**: Fans are typically made using various grades of carbon steel that can cause a spark if components strike each other. AMCA documents specify different levels of spark resistance to minimize the possibility of sparks occurring which can result in an explosion. (Refer to FA/116-08)

6. Special materials: Fans can be made from special materials to minimize corrosion, erosion, extremes in hot or cold temperatures, food service etc. Materials such as aluminum, stainless steel, plastic or fiberglass can be used to satisfy special requirements.

7. Temperature and rate of temperature change: The operating temperature, design temperature and the rate of change in temperature are important design parameters. The rate of temperature change affects the internal stresses created inside hubs and the thermal expansion present in various parts. If parts become loose because of differences in their expansion rate, violent vibration can result destroying the fan. (Refer to FA/109-01)

8. Durability and reliability: This is the degree of ruggedness that takes into account a fan's design to insure long life.

9. Bearing design, cooling, lube: In order to maintain expected L-10 life, bearings must be maintained within certain speed limits, load limits, temperature limits and vibration limits. Special seals may be necessary to keep dirt and contamination out of the lubricant. Lubrication intervals are typically specified as well. (Refer to FA/103-00)

10. Thermal expansion: Materials expand and contract with temperature. Sufficient clearances must be designed into the fan so that components do not interfere or seize. Special mountings may be necessary to allow growth of the housing and not distort shaft or bearing seals. Drive component alignment must be maintained.

11. Erosion: Contaminants in the airstream can cause wear. Wear weakens fan parts. These parts must be replaced at intervals or protected by some sacrificial material. Sometimes harder materials are used to resist wear.

12. Corrosion: Contaminants can eat away or corrode a material resulting in failure. Special materials such as stainless steel, Everdur, aluminum, and fiberglass may be employed to resist corrosion. Many coatings can be applied to protect the base material.

13. Build-up: Build-up occurs when contaminants in the airstream stick to fan parts and build-up over time. This increases the weight, stress levels and can cause severe unbalance when chunks fly off rotating wheel components.

14. Special codes and regulations: The construction of fans is often covered by local or national codes. These may apply to snow loads, wind loads, seismic loads, fire and smoke etc. (Refer to CS/100-99, CS/101-00)

15 Start/Stops: Many start/stops can result in low cycle fatigue causing cracks in the materials of construction.

16. Flow reversal fan: Emergency tunnel ventilation and fire/smoke applications may require the fan produce equal performance in forward as well as reverse direction.

17. Special coatings: Corrosion can be minimized by using base materials inert to the contaminant. Special coatings can be used for protection of the base material as long as no wear exists. (Refer to FA/110-04R)

18. Toxic gases: This condition requires "airtight" construction so that there is no leakage in or out of the fan.

19. Insulation: Insulation on a fan housing can keep heat or cold within the fan or protect the fan from the environment. Insulation can also reduce radiated sound.

20. Motors: Selecting the right motor for a given application is critical. Greenheck's Product Application Guide FA/113-01 will provide information to help select the appropriate motor.

Summary

This article emphasizes the major considerations pertinent to fan selection and application. It is not all inclusive since there are many other considerations not listed. It is always best to take a step back and use common sense as the final criteria. Another source of useful product application criteria can be found in FA/112-02.

Common Applications for Fans

General Ventilation

Air handling fan: A fan that moves large volumes of air or overcomes high pressures. This fan typically moves air through coils.

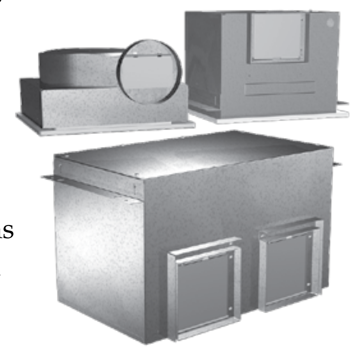
Agricultural fans: A propeller fan in an enclosure with screens that circulates air over poultry or exhausts air from barns.

Attic ventilation fan: A propeller fan that circulates attic air to remove hot air and draw in cooler outside air.

Bathroom fan: A fan that exhausts moist air and odors to the outside.

Cabinet fan: Fan that is mounted inside a cabinet or box that is used in a ducted application. Used to locate fans away form noise sensitive areas.

Ceiling exhaust fan: Fan that exhausts air from utility rooms, bathrooms, meeting rooms, conference rooms to the outside. Mounted in the ceiling.


Ceiling Exhaust Fans

Central (whole) house fan: A propeller fan mounted in the ceiling that exhausts air to an attic while drawing in fresh cooler air through windows of a house.

Combustible fan: Fans that can exhaust air that is combustible, these fans typically have non-ferrous components to prevent sparking.

Cross flow fan: A very wide forward curved wheel in which air enters and leaves at ninety degrees to its axis of rotation. This fan is used in window heating and cooling units and fireplace ventilators.

Energy recovery ventilator: A unit that uses an energy recovery device (wheel or plate) to transfer energy from air being exhausted to fresh outside air entering a building

Exhaust fan: Normally a fan mounted in a plenum or large space that exhausts air to the outside of a building.

Fan terminal unit: A relatively small unit containing a fan with or without reheat coils located in an under the floor or in ceiling plenums to direct air through grills into an occupied space.

Hooded roof fan: a fan that is roof mounted and has a hood that prevents the elements from entering the building.

Horticultural fan: A propeller fan mounted in an enclosure containing screens and a damper that exhausts air from greenhouses.

Kitchen exhaust fan: A fan used to exhaust grease laden air collected by a hood to the exterior of the building. Typically a centrifugal fan.

Make-up air unit: A ventilating unit that contains fans, filters, coils, etc. to condition air being supplied to a space to replace air that has been exhausted.

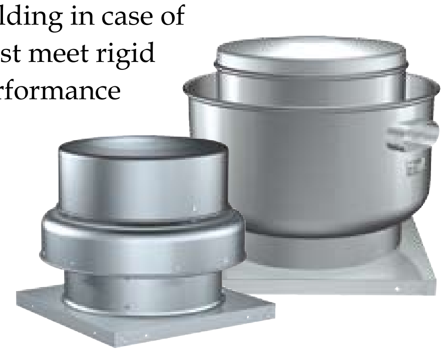
Recirculating fan: Fan that moves the air around within the same space.

Return air fan: Removes air from an occupied space and delivers the air to a mixing box, where the air is recirculated into or discharged out of a building.

Sidewall propeller fan: Fan located in the wall of a building that uses an axial propeller to exhaust high volumes of air with no ductwork.

Smoke exhaust fan: A standby fan that removes smoke from a building in case of a fire. The fan must meet rigid structural and performance requirements.

Spun aluminum fan: Fan that is made mainly of aluminum, exhausts air and is roof mounted. An upblast version is commonly used for kitchen exhaust applications. The downblast is for relatively clean air.


Spun Aluminum Fans

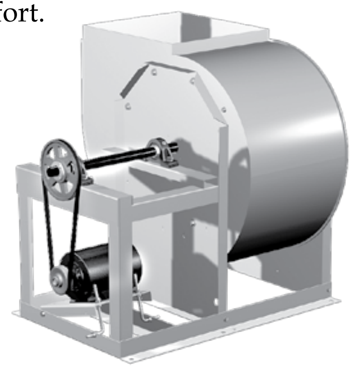
Supply fan: A fan that supplies outside air to an occupied space. Air may be heated, cooled, humidified, or dehumidified during the process.

Tamper resistant fan: Fan that has provisions so it can not be tampered with without internal access.

Upblast fan: A fan that exhausts air up and away from the mounting surface, typically a roof.

Unit heater: A propeller fan and tempering coil unit that heats or cools small spaces to maintain personnel comfort.

Utility fan: A multi-purpose scroll house fan that can be configured for many applications, typically has many outlet positions available.


Utility Fan

Industrial Applications

Bag house fan: A fan that draws dirty air through bag filters in an air cleaning unit similar to a vacuum cleaner but on a much larger scale.

Basic oxygen fan: A fan that supplies a burst of air (oxygen) to a furnace used to make steel. The fan idles for long periods of time and suddenly upon demand supplies the flow of air required.

Bifurcator fan: An inline fan for handling hot or contaminated air where the direct connected motor is separated from the air by means of a compartment or tunnel.

Brake fan: A fan wheel typically running backwards that absorbs power.

Cement or lime kiln exhaust fan: Exhausts air from a kiln drying cement. One of the most severe corrosive and high temperature applications to be found.

Cooling tower fan: A very large diameter axial/ propeller impeller that runs relatively slow while drawing air through or over a liquid to cool it.

Exhaust fan: Removes clean air or contaminated air from an occupied or industrial space.

Forced draft fan: Supplies combustion air to a furnace or burner.

Fume hood exhaust fan: A fan that exhausts air from a hood over pickling, plating or other process and discharges it at a high velocity to the outside.

High pressure blower: A high speed fan that provides a low volume of air at high pressures for processes, cooling, aeration, flotation, etc.

Impulse or jet fan: An axial fan with a high velocity discharge that induces air flow in a long underground tunnel without ductwork.

Incinerator fan: A fan that exhausts fumes, ashes, dust, etc. from an incinerator. These are high temperature and very corrosive applications.

Induced draft fan: A fan that removes flue gas from a furnace or burner and discharges it to the outside or into an air cleaning unit.

Industrial exhaust fan: A heavy duty fan that exhausts air from grinding, buffing, pickling tanks, textiles, etc. At times, these fans may handle solids such as wood chips.

Material conveying fan: A fan that handles air containing small solids or entrained dust.

Mine fan: A fan that supplies air to a mine shaft for ventilation. These fans may exhaust air that contains small solids from the mining process.

Paper fan: A fan with sharpened blades that chops strips of paper and discharges them into a bin or truck for recycling.

Pelletizing or sintering fan: A fan that handles very hot and dirty air from a steel making process that enriches the iron ore charge through coagulation.

Plug Fan

Plug fan: A fan that is mounted in the wall of a dryer or oven. The fan mixes and recirculates the air to maintain a uniform temperature.

Scarfing fan: A fan that blows slag off of red hot steel billets.

Scrubber fan: A fan that provides air at high pressure to clean, aerate and evaporate contaminants.

Spray booth fan: A fan that exhausts air from a paint spray booth to the outside or to an air cleaning process. The air is laden with wet paint that requires a very intensive maintenance program for cleaning the fan.

Supply fan: A fan that provides clean air for ventilation, cooling etc. into a building.

Supply Fans

Traction motor fan: A fan that supplies air for cooling locomotive traction motors. This is a very demanding application due to frequent start-stops and reliability concerns.

Power Plant or Mechanical Draft

Cyclone burner fan: Provides combustion air and produces cyclonic action in the burner and furnace. This increases combustion efficiency.

Flue gas desulfurization booster fan: A fan placed in series with the induced draft fan providing added pressure capability to overcome air pollution devices in retrofit applications.

Fluidized bed boiler fan: Provides air that floats a bed of coal.

Forced draft fan: Supplies air to a boiler for complete combustion. This fan may be required to overcomes losses from the fan to the balance draft point in the boiler.

Gas recirculation fan: Redirects boiler gases increasing mass flow through various parts of the furnace such as superheaters, reheaters and economizers. Tempers hot gases in the boiler to 1900° F. The fan must be sized to overcome losses through the boiler passages and recirculating ductwork.

Indirect reheat fan: Adds clean heated air to the system.

Induced draft fan: Exhaust products of combustion and provides the necessary draft at the fire and to compensate for additional losses to the end of the system.

Tube Axial Fan

Overfire air fan: Delivers air over the fire to improve combustion and reduce smoke generation. This fan reduces forced draft requirements, overcomes piping losses and provides turbulent mixing action.

Primary Air Fan: Transports powdered fuel from the pulverizer to the burner. Provides additional combustion air that makes up for leakage out of the boiler.

Seal air fan: Provides clean air to the chamber surrounding the furnace. Creates a pressure large enough to prevent the escape of dirty gas from the furnace.

Secondary air fan: Provides additional combustion air.

Waste energy fan: Removes hot gases from a waste heat boiler.

HVAC Ventilation Categories and Applications

Major Consideration	General Ventilation	Kitchen Ventilation	Food & Textile	High Temperature Fans	General Exhaust	Fume, Gas or Odor	Conveying Materials	Air Cleaning	Palletizing, Scintering	Mining & Tunnel	Explosive Gases (Combustible)	Incineration	High Pressure Blowers
A. Fan types													
1. Propeller	●			●	●						●		
2. Centrifugal AF, BI, BC	●	●	●	●	●	●		●		●	●	●	●
3 Forward Curved	●	●			●								
4. Vane Axial	●	●	●		●	●				●	●		
5. Mixed Flow	●	●			●	●							
6. Radial, Radial Tipped				●	●	●	●	●	●		●	●	●
7 Paddle Wheel							●	●	●		●		
8. Plenum	●												
9. Inline	●	●	●	●	●	●					●		
B. Rating													
1. High Efficiency	●	●	●		●					●		●	
2. Single or Parallel Operation	●	●			●								
3. Method of Control													
- Dampers	●	●		●	●					●			●
- Inlet Vanes	●				●					●			
- Blade Changes	●				●					●			
- Speed	●	●		●	●	●	●	●	●	●	●	●	●
4. Special Air Density				●	●	●	●	●	●	●	●	●	●
5. Sound	●	●			●			●				●	●
6. Non surge-Stability	●	●	●		●			●					●
7. Capture and Entrainment Velocity					●		●						
C. Design													
1. Location	●	●	●			●		●		●	●	●	●
2. Orientation	●	●				●		●					
3. Vibration	●	●	●	●			●	●	●	●	●	●	●
4. Leakage and Sealing		●	●	●	●	●	●	●	●	●	●	●	●
5. Spark Resistant, Explosive					●	●	●	●		●	●	●	
6. Special Materials			●	●	●	●	●	●	●	●	●	●	
7. Temp & Rate of Temp Change				●	●			●	●			●	
8. Durability & Reliability				●		●	●	●	●	●	●	●	
9. Bearing design, cooling, lube			●	●					●	●		●	●
10. Thermal Expansion				●			●	●	●	●		●	
11. Erosion (wear)					●		●	●	●	●		●	
12. Corrosion					●		●	●	●		●	●	
13. Build-up					●		●	●	●	●		●	
14. Special Codes & Regulations		●	●		●	●	●	●		●	●	●	
15. Start/Stops										●		●	
16. Flow reversal fan										●			
17. Special Coatings			●		●	●	●	●		●			
18. Toxic Gas					●	●		●			●	●	●
19. Insulation				●					●			●	