PRODUCT APPLICATION

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

Fan and System Troubleshooting — A Guide to Characteristic Field Problems

Troubleshooting is the effort to identify and resolve differences between design intent and actual performance. This article is a guide for identifying the most common problems encountered in fans and air handling systems. Troubleshooting is often an "art" and not a "science" because many problems are subtle and hard to diagnose. It often takes a lot of knowledge, inquisitiveness, common sense, mechanical aptitude, and years of experience to diagnose the cause of some very subtle problems. A professional consultant may ultimately be required to identify and solve the worst problems. This article assists the reader in identifying possible solutions.

Safety considerations

Fans and air handling systems come in many sizes, shapes, and complexities. It is critical to realize the limitations of any investigation so that the safety of all personnel and the safe operation of installed equipment is ensured. Operating a piece of equipment or system when there are obvious mechanical, electrical, or aerodynamic instabilities requires extremely good judgment, and investigations should be conducted by qualified personnel only. Catastrophic failure resulting in death or serious physical damage can occur when rotating equipment is involved.

Physical inspections should be made **only when the fan and system are shut down and locked out** both electrically and mechanically so that windmilling cannot occur. It is strongly recommended that the Air Movement and Control Association International Inc. (AMCA) Publication 202 "Troubleshooting" and AMCA Publication 410 "Recommended Safety Practices for Users and Installers of Industrial and Commercial Fans" be thoroughly read prior to any investigation. Reference should also be made to the manufacturer's installation and maintenance literature. The Occupational Safety and Health Administration (OSHA) requirements for guarding should also be reviewed. Proper attire such as safety shoes, hard hats, safety glasses, no ties or loose-fitting clothing, safety harnesses, etc. must be worn. In no case should the troubleshooter become part of the problem due to a lapse in safety.

Required information

Equipment Identification—It is vitally important that the equipment in question be properly identified along with other related information. This allows the equipment manufacturer's records to be accessed allowing a starting point for an initial evaluation of the equipment at the time it left the factory. The following information is necessary:

- Customer Name
- User
- Jobsite Location
- Fan Serial Number or Order Number
- Fan Model
- Specific fan designation (Tags or Marks) if several fans are involved.

Detailed Description of the Problem—It is essential for those involved to properly describe the problem in an as detailed and clear manner as possible. Information is often transferred through several different people and "word of mouth" alone is normally not sufficiently accurate. Complete descriptions including noises are encouraged to be reported as they can be very helpful in identifying a problem. As many details as possible should be included.

As an example, if a system is low in airflow, related rating parameters such as inlet and outlet pressure, motor power (voltage and amperage), fan speed, elevation, and temperature should also be provided. A statement of the actual measured airflow compared to the specified and/or desired airflow should be included. Test measurements and their locations are very useful since the measurements themselves are often a clue to the problem.

Initial Fan and System Inspection—Most problems occur during the start-up phase of any installation. Many of the simpler problems can be solved up front by conducting a thorough inspection. This is normally the user's responsibility prior to getting others involved. It is important to obtain and review the original approved submittal for the fan or fans involved for reference. The following checklist from AMCA 202 contains the items to be inspected:

- All fan parts and accessories should be installed, aligned, and operational.
- Check all tie-down bolts so that the fan is firmly held in place on its foundation.
- Check all ductwork connections so that flexible material does not "suck in", leak, or become short-circuited by having the fan support ductwork or other parts of the system.
- Check that all driveline components such as bearings, couplings, V-belts, motors, etc. are aligned and properly tensioned. Make sure all V-belts are matched and that bearings have been tightened to the base and to the shaft. Check that bearings are properly lubricated with the proper type and amount of grease.
- Check that the fan wheel is properly aligned with the inlet bell and housing, is free to rotate, and that when momentarily energized it will rotate in the correct direction.
- Check the fan and system for any obstructions, build-up, leaks, missing parts, etc.
- Run the fan at full speed. Verify that the fan is running close to the design speed. Determine whether the fan is running smooth and that the bearings are not running hot. Obtain a power measurement (voltage and amperage) to make sure the fan is not overloading the motor.
- Let the fan run for 24 hours. Recheck all of the items listed above once again, particularly the V-belt tension.

The results of this initial inspection should be kept on record for future reference. If a problem does occur later on, it will serve as a beginning point of any evaluation.

Contact Person—If there is a problem, it is necessary to designate an individual as a contact person who will have continuing intimate knowledge of the fan and system status, knows the problem, and what has already been tried to solve it. This person is to serve as the contact person and liaison for others who may be required to visit the jobsite. This person's name, title, address and phone number should be readily available and that person should be kept apprised of all actions that may be contemplated.

Problem Priority—There must be some determination as to the seriousness and timeliness of the problem resolution. Many misunderstandings occur when a priority has not been established. All of those involved in the resolution must recognize that a problem exists and that an amiable plan of action and solution is usually in the best interest of everyone.

Problem categories

As previously stated, this article is intended to guide the troubleshooting process in the right direction. Required information has been outlined. It is now necessary to identify the nature or category of the specific problem. The following four categories narrow the focus of attention and speed up the evaluation process.

Aerodynamic Performance—This applies to any of the five rating parameters of flow, pressure, speed, power, and density, and how they compare to their respective design quantities.

Noise—This applies to any problem in which the ears are the main sensor. Noise and vibration are similar in that they both have amplitude and frequency, but noise has a much lower amplitude and energy content and is measured in dB referenced to Watts. Generally speaking, noise has a much wider frequency range and a higher upper limit than vibration (63 Hz to 10 KHz).

Vibration—This applies to any problem in which the hands or touching are the main sensor. Amplitude is large when there is a problem. It has a much greater energy content with a smaller frequency range (3 Hz to perhaps 500 Hz).

Premature Failure—Premature failure applies to anything whose life does not meet that which was expected. The term “failure” does not necessarily mean a catastrophic failure such as when something “blows up”, but a length of time considered as being the useful life of the component.

Summary—Satisfactory applications occur when all aspects of the installation are in harmony with each other. Proper orientation, constant monitoring, and maintenance are also part of the equation. Troubleshooting must be employed when one of these areas becomes a problem.

Aerodynamic Performance Troubleshooting Symptoms			
Symptoms			Possible Causes
Flow	Pressure	Power	
Low	Low	Low	• Speed is lower than design, V-belts, slipping, wrong sheaves, Variable Frequency Drive (VFD), and/or VFD controls • Air temperature is higher than design • Suction pressure correction not included in density calculation • Swirl in direction of rotation, elbows on fan inlet • Accessory losses not included in fan rating • Axial fan blade settings lower than design • Damper mounted directly on fan outlet • Failure to include plenum losses in rating • Insufficient length of duct on fan outlet
Low	High	Low	• System losses higher than design, blockage, dampers closed, dirty coils, dirty filters • Fan operating in stall behind peak pressure
High	Low	High	• System losses lower than design, components missing, leaks
High	High	High	• Speed is higher than design • Air temperature is lower than design • Swirl opposite to fan rotation, inlet elbows • Wrong wheel rotation (CW versus CCW, etc.) • Fan running backward • Axial fan blades set higher than design
Normal	Normal	High	• Undersized motor • Excessive driveline losses, wheel or seal rubbing, tight bearings, too many oversized/misaligned V-belts • Motor misaligned, wrong voltage, wired wrong • Improperly matched motor and VFD controller
Unsteady	Unsteady	Unsteady	• Fan blocked off, operating in stall or on unstable part of curve • Fan and system hunting due to flat portion of curve • Fans in parallel and not rated properly

Noise Troubleshooting General Considerations

Noise Characteristics

Pure Tone
Whistles
Just Plain Loud
Rumble
Pulsating
Hiss/White Noise
Beating

Aerodynamically Generated

Blade Frequency
System Effects
Controls, (Variable Inlet Vanes (VIVs), Dampers)
Turbulence
Vortexing/Whistles
Stall
Surge/Pulsations
Hunting
Rumble
Hiss

Rattle
Scraping
Banging
Screeching
Clicking

Mechanically Generated

Components
Housing
Wheel
Shaft
Bearings
Sheaves
V-Belts

Hum
Whine
Chatter

Electrically Generated

Motor
VFD
Relays
Starters

Noise is generally considered low-quality, unwanted sound. The ears sense noise whereas vibration is sensed by touch or feel. Sources of noise can usually be identified by some form of characteristic sound to which we can relate. Words such as tone, rattle, pitch, steady or unsteady, and intermittent are examples. These characteristic words help to define whether the source of the noise is aerodynamic, mechanical, or electrical.

Aerodynamic-generated noise is characterized by a continuous broadband frequency spectrum with a superimposed tone. The tone is typically objectionable when it becomes 4 to 6 dB louder than the rest of the spectrum. The tone can be the blade frequency, which is a function of the fan type. It can become very objectionable when system effects and various controls cause it to rise higher than normal. Additional causes include turbulence, high velocities, and instabilities due to pulsation and surge.

Mechanically generated noise has a different sound quality and characteristic. It has a metallic sound caused by metal-to-metal contact. This contact may be constant or intermittent.

Electrically generated noise is a function of motors, relays, controls or unbalanced line voltages into the motor. Sometimes improperly matched VFD and motors can cause a substantial increase in the motor noise due to imperfect sine wave simulation. Additionally, motor bearings can be pitted (damaged) by capacitive EDM currents which can occur in all motors run on VFDs, regardless of their size.

Vibration Troubleshooting Index

General Considerations

Aerodynamically Generated

Turbulence
Pulsations
Surging
Blade Frequency
Rotating Stall
Vortex Shedding

Mechanically Generated

Imbalance
Resonances
Looseness
Rubbing

Components
Housings
Wheels
Shafts
Bearings
Sheaves
V-Belts
Motors

Electrically Generated

Torsional Fluctuations
Eddy Current Induced Field
Incorrect Wiring

Components
Motors
VFD Controllers

Many different sources can cause vibration. One of the most difficult tasks in troubleshooting fans and systems is the systematic identification of vibration characteristics (amplitude, frequency, location, direction, units of measurement) as a function of operating point location on the fan curve and control settings. Identification of the source can be extremely difficult, in some cases requiring the services of a professional troubleshooter.

Vibration in housings and ductwork is most often aerodynamically generated. This is a forced vibration in which the energy and characteristics of the airstream are large enough to cause sympathetic vibration in the housing and ductwork. Turbulence, pulsation, and the blade frequency tone are examples of forced vibration due to aerodynamics. Vibration can also be the result of resonance. This occurs when the natural frequency of a duct or housing panel coincides with a specific aerodynamic excitation such as rotating stall, vortex shedding, or the blade frequency if it is strong enough.

Mechanically generated vibrations occur from unbalance, resonance, looseness, and rubbing. Electrically generated vibrations result from torsional fluctuations, eddy current-induced fields, and improper wiring.

Premature Failure Troubleshooting Symptoms

Component	Possible Causes
Housings	• Paint or coating failure resulting in corrosion • Fatigue caused by loose parts which break off • Fatigue caused by turbulence • Lack of attachment to foundation • Ductwork or other equipment attached to fan • Improper storage
Wheels	• Loose rivets or bolts • Long term imbalance • Wear or corrosion • Loose attachment to shaft • Uneven build-up on wheel
Shafts	• Bent shaft causing long term vibration • Undersized shaft causing looseness at wheel, bearings • Undersized shaft causing operation near shaft critical • Improper storage
Bearings	• Lubrication: too little, too much, contaminated, wrong kind • Shaft to bearing clearance too large • Axial thrust too large • Minimum radial load not maintained • Belt pull too large due to small sheave • Too many V-belts • Operating or ambient temperature too high • Improper storage
Sheaves	• Loose attachment to shaft • Wrong V-belt cross section • V-belt tension not correct • V-belt misalignment • Too many start-stops
V-belts	• Under designed to take power • Incorrect tension or not matched, misaligned • Belt speed too high • Operating or ambient temperature too high
Motors	• Overloading of motor • Incorrect voltage • VFD controller lines too long causing voltage spikes • VFD controller and motor not matched causing eddy current induced fields and bearing pitting • Belt pull too large due to small sheave, too many belts • Wrong motor enclosure for environment

Premature failure general considerations

It is obvious that a component that physically fails and flies apart upon start-up is a premature failure. However, premature failures also occur when fans and components do not satisfy their expected life. This is hard to quantify because very few records are typically kept and once a fan is installed it is easily forgotten. The best prevention against premature failure is a good conscientious preventative maintenance program that includes inspections and the recording of vibration levels. Repairs should take place at the first sign of a problem, and not after damage has occurred to other parts.

In general, the equipment life should be consistent with the application. As an example, HVAC equipment may be expected to last 15 - 20 years. This means that the equipment itself, with proper maintenance, should still be around after these time frames.