With many years of field experience in the industrial cooling fan business we have found that most clients require a simple explanation regarding fan related vibration. The reason for this paper is to help simplify heat exchanger and cooling tower fan vibration issues, for fan sizes 5ft to 40ft in diameter.

Testing structural natural frequency set on displacement

The focus is on three main causes of vibration any or multiples of:

1. Fan Speed
2. Beam Pass/ Blade Pass
3. Motor Speed

For fan diagnosis, take the readings with your analyzer set to "Velocity RMS, inches/second," as per API 661-5th addition 7.3.2.4. For typical axial fan speeds <600rpm, the maximum velocity shall not be over 0.25"/s RMS (0.35"/s peak to peak). Use a 0 to 30Hz accelerometer (for clear view of the low amplitude). Take readings perpendicular to the fan shaft at the structure or at the top fan bearing. If possible, also check in the horizontal position. Additional readings can be evaluated in the vertical and axial position to assist with a complete report. If the structure is suspect then measure in "Displacement" as per this picture. API 661-7th addition, 7.3.2.1 states a maximum permissible amplitude of .006" (0.15 millimeter) peak to peak, as measured on the primary structure.

Vibration at fan speed: This is an indication that there is an issue with the fan in general. Moment balancing of the fan blades to ISO 1940-1 grade G6.3, performed at the factory during assembly, has an allowable tolerance that can cause small amounts of imbalance that is usually acceptable for operation. Experience dictates that the fan is fine but the installation is suspect.

Reviewing the analyzer spectrum: If the peak is higher than 0.25 in/sec at fan speed perform the following inspections:

- **All blade pitches to be within +/- 0.20° of each other**
- **Blade tracking should be within ½" between the highest and lowest track profile**
- **Blade sweep: The positioning of the blades in the neck clamps is not extremely definitive. There is a slight bit of sweep variance between blades, measuring from trailing edge to the next blade trailing edge. These should be exact as possible**
- **Debris inside the blade (usually can be cleaned out by cleaning the blade-tip weep holes)**
- **If blades are not fully pulled out in the radial direction against the clamps, this can cause fan imbalance**
- **If the fan has rubber bushings and the rubber blocks are old, they may need to be changed or full blade replacement is needed**

If these areas all check out within tolerance, and if you still have a vibration issue, then the fan is going to need to be balanced. All fans are imbalanced to some degree. Even the slightest variation in blade pitch angle between blades causes thrust imbalance, which results in some fan imbalance. Dynamic fan balancing is a simple way of fixing the problem, but it is usually doubtful that fan imbalance was the entire cause. There are plenty of documented procedures for field balancing fans. Your best option is to hire a contractor with experience.

Beam Pass/Blade Pass: If the vibration is at fan speed x the number of blades, there could be a resonant frequency close to the fan rpm causing the problem. Reducing the driving force (fan imbalance) is a simple method to remedy. Measuring natural frequencies on the structure in various directions and locations can get quite complicated with limited access. Also, other fans, with different mass, turning different speeds, may be adding to the vibration. You can test this condition by either changing the fan speed or the number of blades, as part of your diagnosis. If you have a VFD, this is easy to check. Talking about VFD's we need to always worry about a bad speed like the 1rst mode as it passes the blade pass frequency. There is an easy procedure for this so you can block out the bad speed(s) in the VFD. Be sure this gets performed when you have a VFD and an axial fan.

Beam pass is the number of times per revolution that one fan blade passes over a beam or strut. Thought of as, "how the structure interacts with the fan blade" expressed in cycles/sec (Hz) or cycles/minute (CPM). Normally this is commonly the highest peak in your spectrum.

Motor speed vibration: If the vibration is at motor speed this indicates how the motor interacts with the structure. If this peak is higher than 0.25"/s then look at the alignment, gearbox soft foot, belt tension and bearings. If these check out to be within specification then check for structure natural frequencies matching the motor speed.

The next page is a great tool to help check axial fan issues related to installation. This is more geared towards fixed-wing fans, but flex-fans also need to be set up correctly, especially having all the fan blades pitches close and not in a stalled condition.

Fin Fan Check if there is a system vibration issue

Mark fan blade numbers with mark on each fan blade

Fan Blade Pitch

Mount Protractor on Flat bar as base and place it approximately 1" from tip of blade.

Fan Pitch Design: _____

Blade #	As Found	After Adjustment
1		
2		
3		
4		
5		
6		
7		
8		

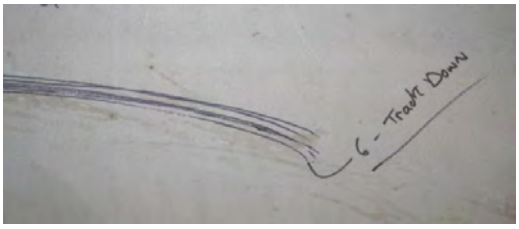
Pitch must be within +/-0.2°

Fan Blade Tracking

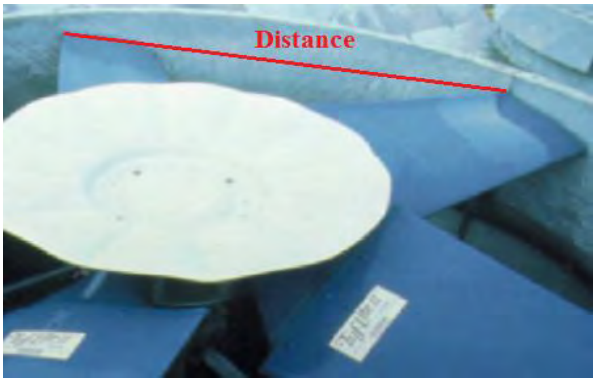
Trace each blade with maker onto plenum.
Mark Lines with Blade number.
The difference between levels of highest and lowest outlets should not be more than 1/2"

As Found	After Adjustment

Tracking must be within 1/2"



Fan Blade Sweep



Measure From trailing edge to trailing edge of the next blade. All sweep measurements must be within 1" of each other.

Between Blade #	As Found	After Adjustment
1-2		
2-3		
3-4		
4-5		
5-6		
6-7		
7-8		
8-1		

Sweep must be close

Max Running AMP Reading

Amp Reading Before _____ Amp Reading After _____