Comments responding to Doc7 about “Vertical Motor Vibration on Air Cooled Condenser”

OP (Doc7): “Are standard vibration severity charts applicable to motors vertically mounted on a gearbox over an ACC axial flow fan?”

ISO 10816-1 for large machine on “soft foundation” the Normal Limit is 7.1 mm/sec RMS or about 0.4 in/sec peak velocity. This standard should be applicable since it applies to broad-band overall vibration level and does not stipulate that origin of vibration is directly produced by motor. The motor vibration would be much lower if run uncoupled on ACC bridge deck or on shop floor. When motor is part of a machine (motor-gear-fan) then its mass-stiffness characteristics contributes to the resonant structural vibration that can cause excessive dynamic force and stress on gearbox components.

OP: “I have several dozen 1800 RPM motors mounted on single-reduction gearboxes to fans with nominal speed 102 RPM. We are seeing 0.6 to 1 in/sec pk overall values on the outboard (upper) bearing of the motors (all) and the spectra show that the most influential peak is at blade pass frequency, or 7X running speed of the fan. These fans utilize VFDs and we have experimented from 40-60 hz output of the VFD as well as performed impact testing on the motor casing (which showed resonance @ 715 CPM - or close to it, for each motor in the condenser); once dropping below 56 hz and getting farther away from a blade pass frequency overlap with natural frequency the overall vibration numbers are substantially lower. These results are the same whether a single fan is running or a dozen on the tower simultaneously.”

The highest vibration from blade rate pulsation generally occurs on warm days with high wind velocity. Some fans will be more susceptible to high winds than others depending on wind direction and other features of the plant site that affects wind velocity. It is unfortunate that there is a resonant structure corresponding to full fan speed, because for fan speed is needed during warm weather to maintain the greatest condenser vacuum as possible. Vibrations should be measured on the upper motor bearing in both directions (parallel to bridge deck and perpendicular to bridge deck), since natural frequencies can be dominant in specific directions. It is also necessary to make peak amplitude readings or take averages over time to quantify vibrations caused by wind gusts.

OP: “This plant is currently under construction by the EPC, and ACC testing has only just begun. The tower manufacturer has seen our results and indicated that “0.6-1 IPS vibration at the motor outboard bearing is normal due to its location 5 feet above the gearbox-mounted vibration switch which is the proper place to measure vibration.”

Vibration levels in excess of 0.6 in./s are not normal, especially when you have direct measurement evidence that vibrations are much lower at a slightly lower than the. High vibrations should not be accepted especially at full fan speed, especially when vibration levels drop significantly when fan speed is reduced. It is also important to identify by measurements torsional natural frequencies that can occur within the operating speed range. Any statements made by the tower manufacturer and the fan components vendors should be carefully evaluated. Their objective is to get the equipment accepted by the owner for service without further modifications. You can ask the vendors for extended warranties and for technical justification for any statements made; good luck with that!

W. Strong

ACC Fan Vibrations
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OP: “I understand that this may be the case for standards for power generation ACCs which are primarily focused on fan balancing, but I am hoping to understand and be able to explain to others that a 0.6-1 IPS vibration at blade pass frequency on the motor rocking due to the structural conditions is detrimental to the long-term reliability of this equipment. The standards I have found on ACCs discuss measurements on gearboxes but I can't find a specific reference to the motor itself.”

The tower manufacturer and the industry in general do not focus on motor vibrations because they are generally high. They would much rather measure vibrations where they are low. Gearbox reliability is an industry problem and may be directly correlated to high vibrations, both lateral/rocking and torsional.

OP: “I am not attempting right now to come up with a fix - only to understand the proper standard to reference for acceptable motor vibration that is not caused by a motor bearing failure but instead is being caused by the driven equipment, and then go from there. It seems that the vendor is saying that because it isn’t a failed motor bearing and the vibration is being caused by the fan that it is normal and acceptable to see a vibration of this amplitude.”

A lot more could be discussed about ACC fan vibrations. I spent over two years providing consulting engineering services for a new cogeneration plant with an ACC with 10 fans. Each of the fans had the following characteristics:

- 7 FRP blades 34 feet diameter
- 91 rpm full speed
- Two-stage parallel shaft gearbox on rubber mounts

AC motor TEFC Frame 447 TD rated 250 hp at 1780 RPM with VFD speed control

My services included:

- Conducted vibration surveys including sound pressure measurements of all 10 fans
- Conducted variable speed tests with an eight channel data acquisition system measuring motor speed, motor and gearbox vibrations, torque/horsepower, dynamic torque (torsional vibrations) and sound level (dynamic pressure).
- Conducted operating deflection shape vibration test (ODS)
- Conducted structural impulse-response vibration tests for natural frequencies motor-gearbox, bridge, and fan blades
- Diagnosed gearbox bearing defect from recorded sound by plant personnel
- Participated in numerous meetings and conference calls with plant personnel, equipment vendors and tower manufacturer’s consultant
- Witnessed inspection of gearbox repairs at manufacturer’s facility
- Developed vibration control methods and recommended materials
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