Informative Application Guidelines, with respect to *Motors & Drives* to keep you better INFORMED.

APPLICATION GUIDELINE #08

(Direct Coupled Alignment)

…….Brought to you by your Motor & Drive Specialists

Effects of Coupling Generated Forces on Motor Bearings

Anti-friction bearings used in direct-coupled applications are typically designed to provide an L10 life of at least 100,000 hours. This life is assuming that the bearings do not support any external load other than the weight of the rotor and the half coupling.

If the motor is mis-aligned or the coupling is locked up, its bearings will be subjected to axial load and the bearing life will be reduced. Depending on the external loading, the life reduction can be dramatic. As an example, consider a hypothetical 500 Hp, 3600 RPM motor that has a 6315 ball bearing on the drive end, which is the fixed bearing. (The opposite drive end bearing is free to move axially to account for thermal growth of the shaft). Since the drive end bearing is fixed, it will be subjected to any external axial forces. The L10 Life versus External Axial Load curve is shown in Fig. 1 below.

L10 Life versus External Radial Load curve is shown in Fig. 2 below. These graphs represent a specific design of bearing housing and a specific bearing. Different combinations of design and bearing size will have different life versus load characteristics but all motors will be affected adversely. In the worst-case situation, the coupling can exert both axial and radial loads on the motor shaft at the same time.

L10 Life versus Axial = Radial Load is shown on the curve in Fig. 3 below. With the motor used in the Life versus external load examples, the shaft stress limiting external load for infinite fatigue life for even a mild steel shaft would be 1,400 lbs. exerted at the end of the shaft. With this amount of load the drive end bearing life would be 11,300 hours in the case of the coupling exerting radial load only and 1,865 hours in the case where the coupling exerts an axial load equivalent to the radial load. These values are off **where Axial load = Radial load,** the charts in Figs. 2 and 3 below. It is unlikely that the coupling could generate 1,400 lbs. of force, however, even at a much lesser load, such as 300 lbs., where axial load equals radial load, the L10 life drops off to 26,000 hours. This life would not normally be acceptable for direct connect duty.

Coupling forces due to misalignment is often accompanied by vibration. This vibration may be misinterpreted to be motor-generated. Eventually, vibration will increase as the bearings deteriorate. Refer to Table 1 to assist in troubleshooting vibration related to coupling misalignment.

Fig.1 L10 Life versus External Axial Load

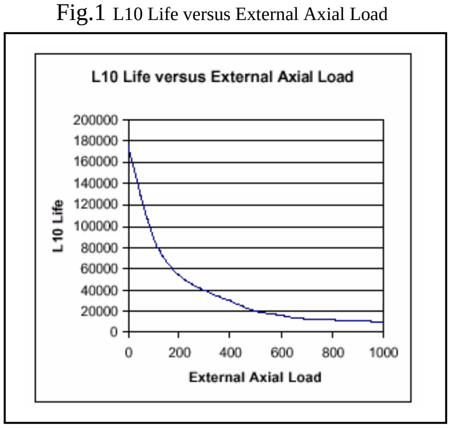

Fig.2 L10 Life versus External Radial Load

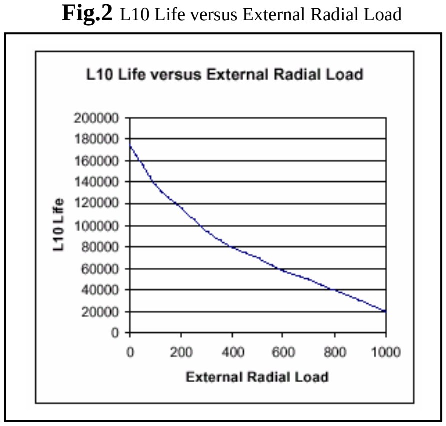

Fig.3 L10 Life versus Axial = Radial Load

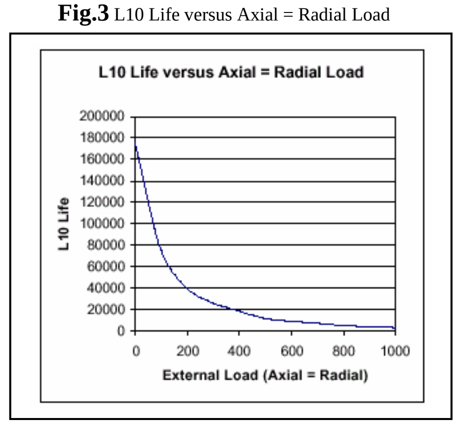

Table 1. Coupling Related Vibration Diagnosis						
Probable Source	**Disturbing Frequency**	**Dominant Plane**	**Phase Angle**	**Amplitude**	**Envelope Characteristics**	**Notes**
Parallel coupling misalignment	1x, 2x, 3x possible	Radial	Radial 180°C out of phase	Steady	Narrowband	1
Angular Coupling misalignment	1x, 2x, 3x possible	Axial	Radial 180°C out of phase	Steady	Narrowband	1
Parrallel and angular coupling misalignment	1x, 2x, 3x possible	Radial and Angular	Bothl 180°C out of phase	Steady	Narrowband	1
Coupling Unbalance	1x	Predominantly radial (especially at DE) some axial	Radial: unsteady Axial: In-phase	Steady		2
Anti-Friction bearings	Early Stages: 30k-80k Later Stages: High 1x & multiple harmonics	Radial (some axial in thrust bearings)		Increases as bearing degrades	Bandwidth broadens as bearing degrades	3
Sleeve Bearings – Journal out of round	2x common 1x, 3x possible	Radial	4	Increases as bearing degrades		4
Sleeve Bearings – Oil film instability	1/2x	Radial	Unstable	Steady	Discrete peaks	
Seal or bearing rub	Sub harmonic or multiple-high harmonics	Radial	Unstable	Unsteady		5

Notes:

1. **Most misalignments will be a combination of parallel and radial misalignment. Amplitude of vibration will vary with power transmitted through the coupling.**
2. **Amplitude of vibration will vary with speed. Often times, unbalance is due to the key.**
3. **Vibration frequency given by ball pass frequency for inner and outer race and cage pass frequency, which is dependent in bearing ball compliment (i.e. internal bearing geometry). This information must be obtained from the bearing manufacturer.**
4. **A shaft proximity prove can be used to indicate dynamic changes in shaft position and thus phase angle.**
5. **As speed is reduced, vibration suddenly disappears at certain speeds. Full rubs tend to be in the 1/2x to 2x range.**