43rd Turbomachinery
30th Pump SYMPOSIA
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MORTON-LIKE EFFECT IN A CENTRIFUGAL PUMP

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Morton-Like Effect in a Centrifugal Pump

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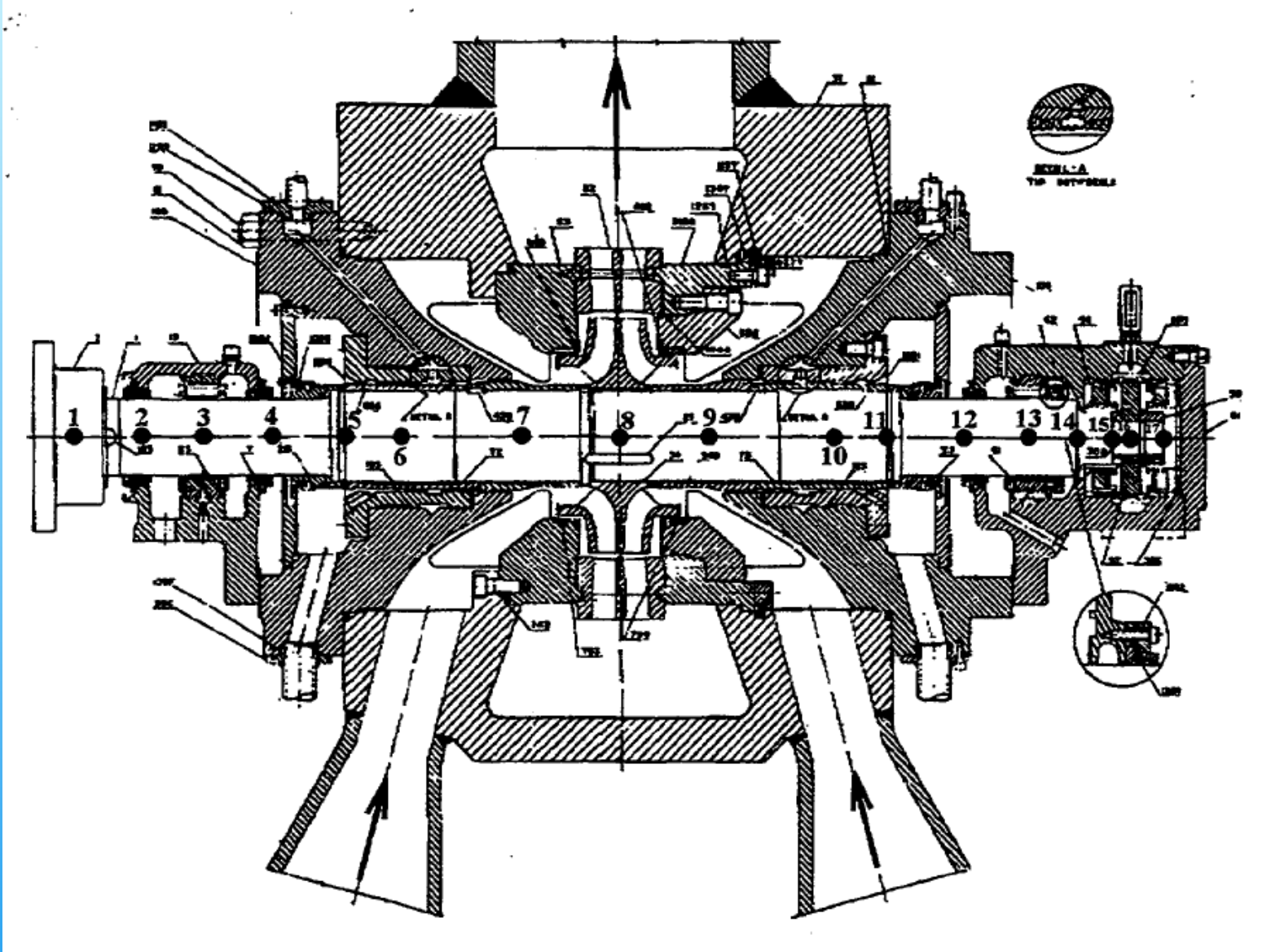
- Co-Author Pump Vibration Chapter, McGraw-Hill Pump Handbook
- Member of ASME and the ISO TC108/S2 Standards Committee for Machinery Vibration

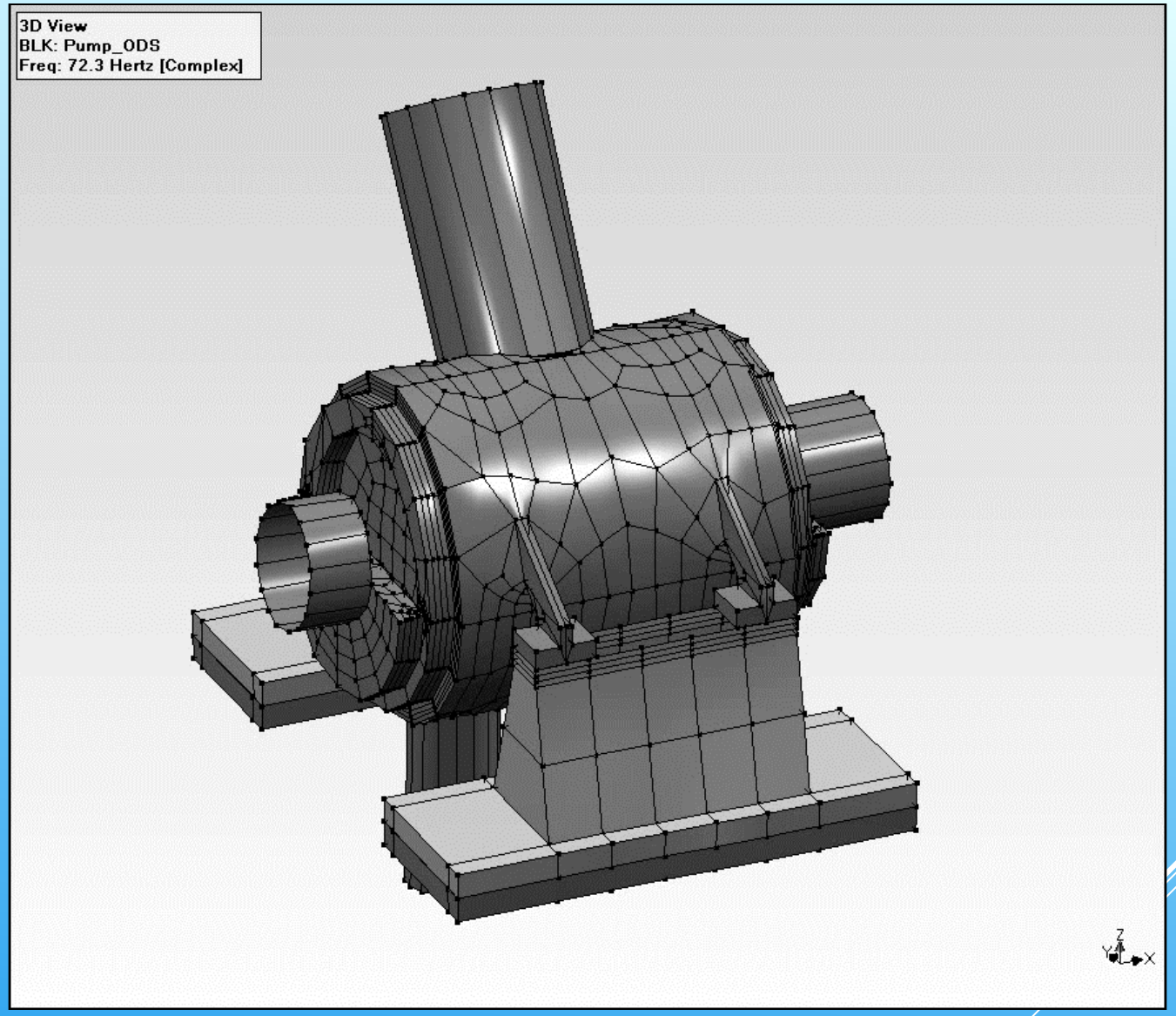
Background

- Two 50% capacity (Pacific 20x17 HVF) pumps were installed in 1984 in a nuclear facility in Louisiana. The pumps were designed with a single-stage double-suction arrangement in feed water service, driven by a steam turbine. Pump rotor supported by tilting pad bearings.
- February 2011 one of the pumps indicated a step change in 1x rpm vibration accompanied by a significant change in performance. The 1x rpm vibration level increased from 1.8 to 6.5 mils pk-pk. Simultaneously, flow rate decreased from 22,400 to 21,600 gpm. This issue was a result of a broken impeller vane causing imbalance and rubbing.
- April 2012, after a major outage, the same pump began increasing shaft vibration at the inboard and outboard end. The pump was completely refurbished during the outage.
- The vibration amplitude was not constant. The overall amplitude was fluctuating with a period between 10 to 60 seconds.

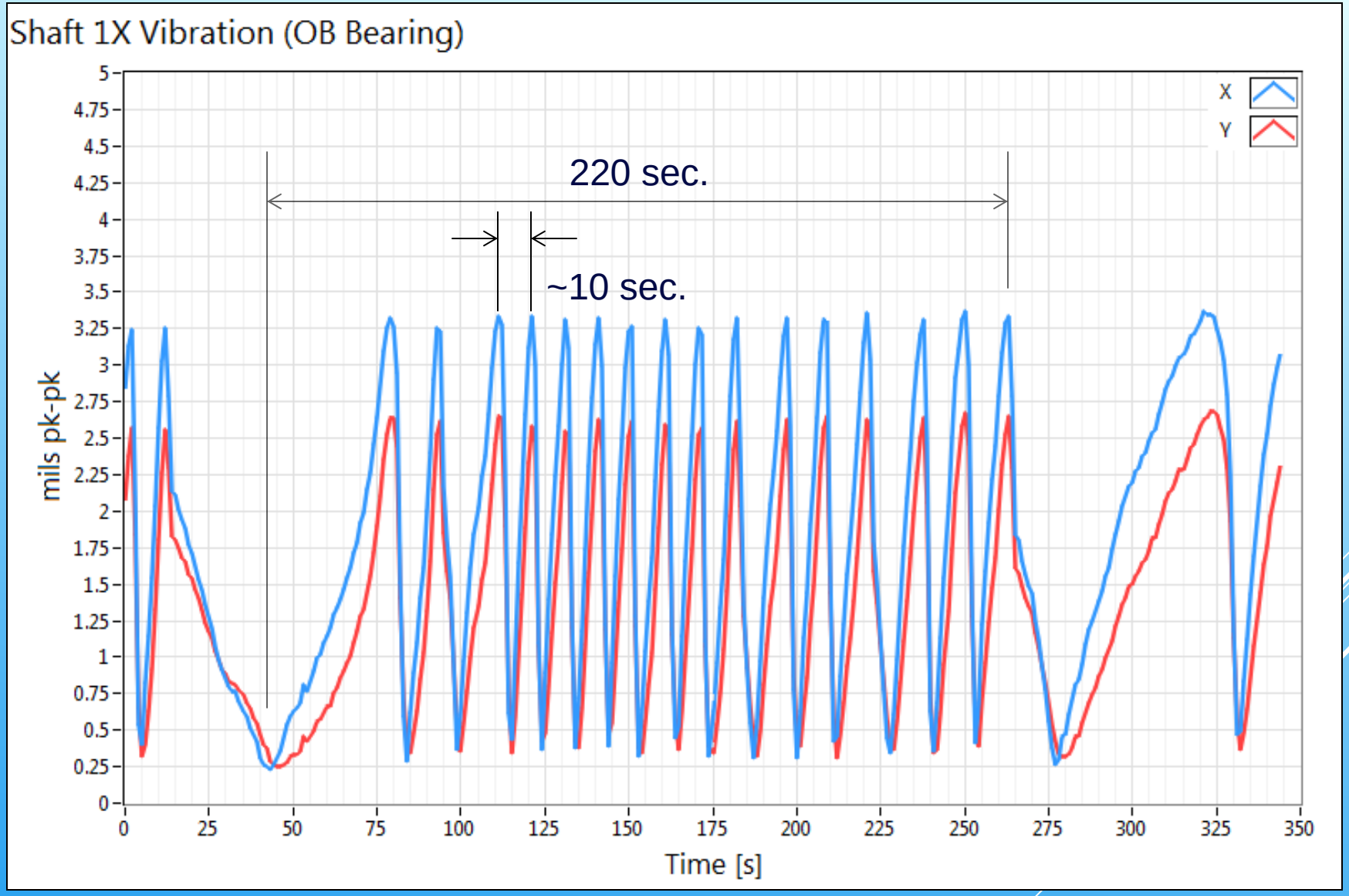
Cross-Sectional Drawing



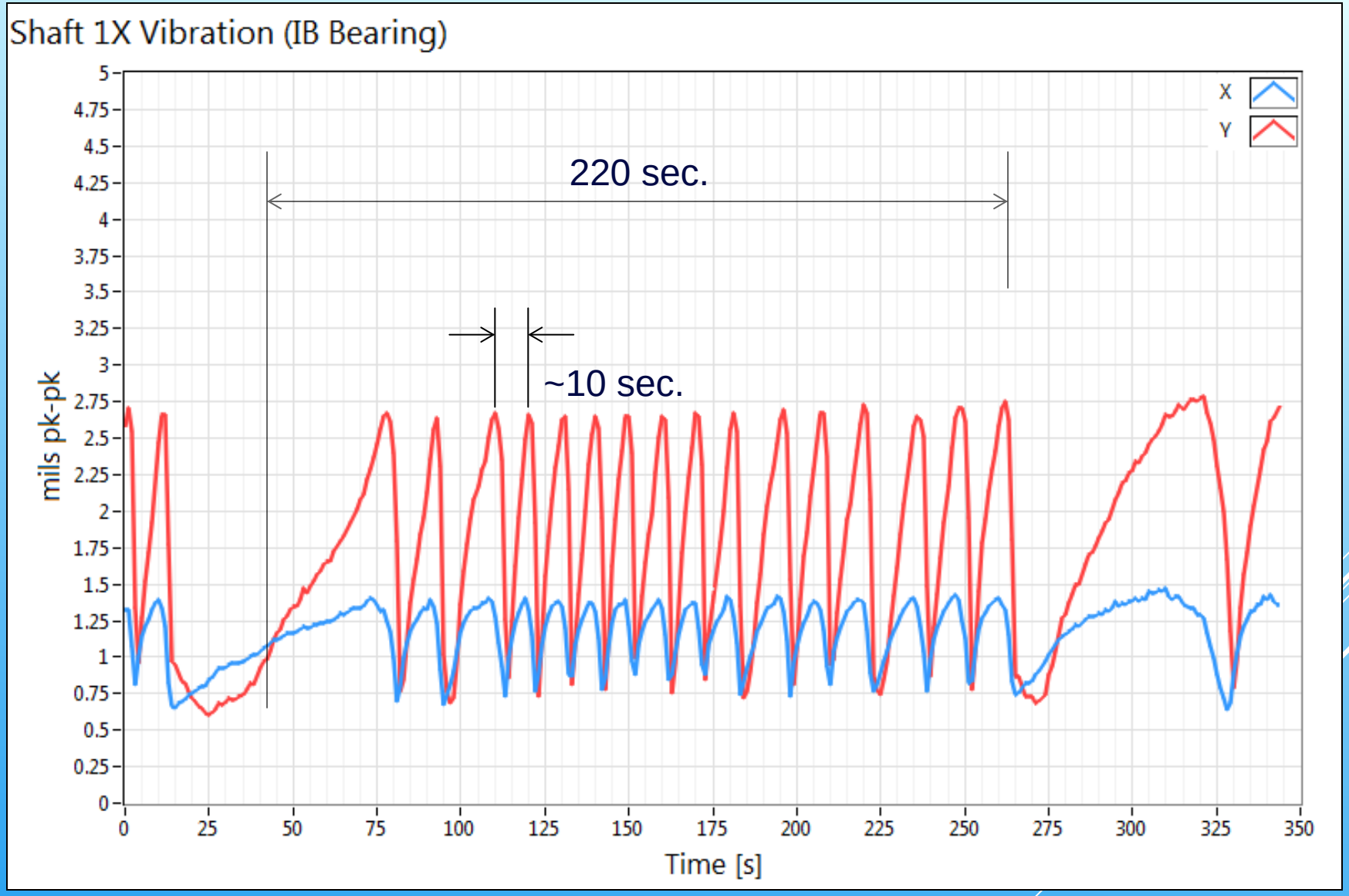
ODS Animation at 1x rpm (72.3 Hz)



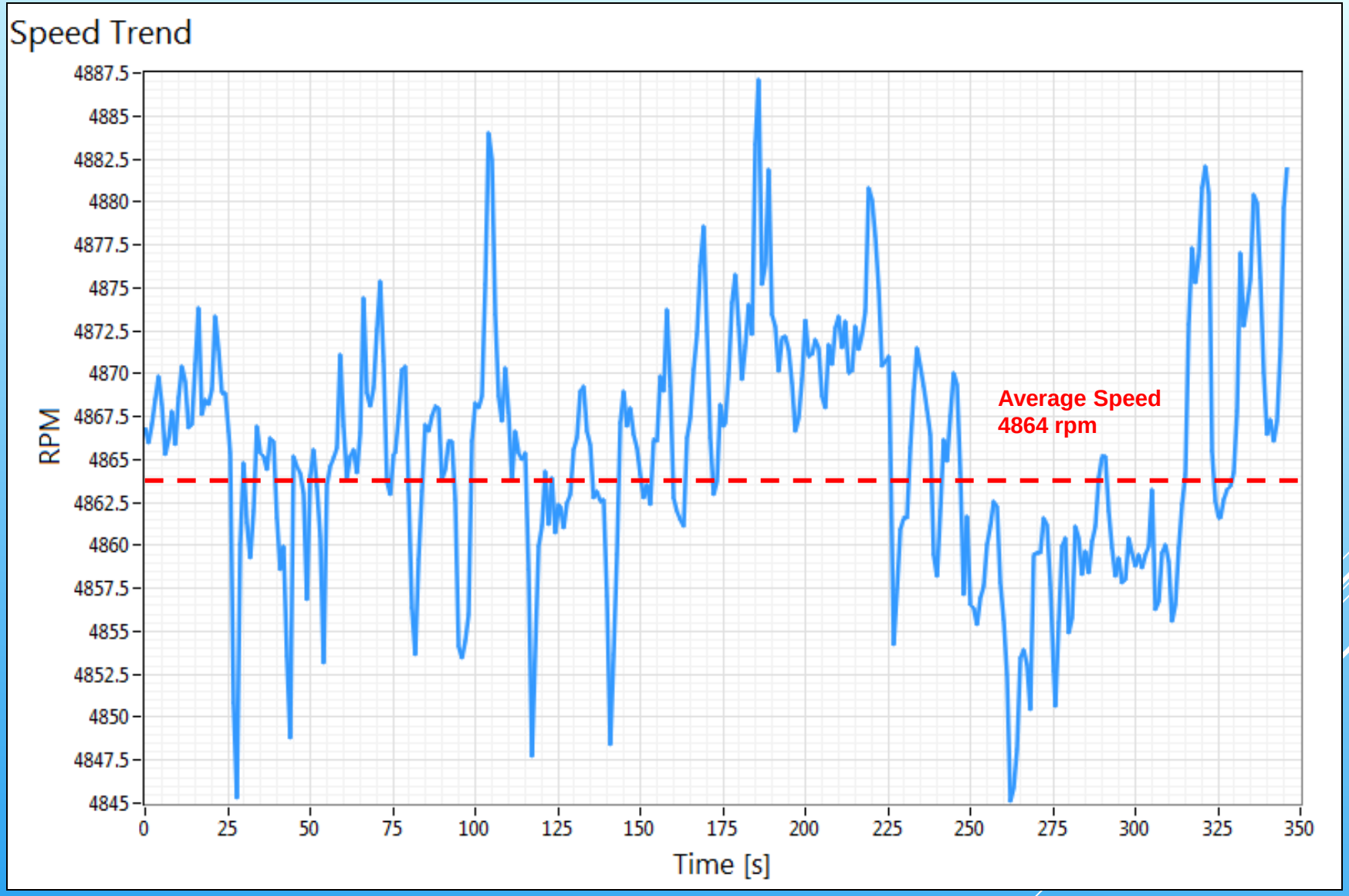
Vibration Testing – Shaft OBB Vibration Trend



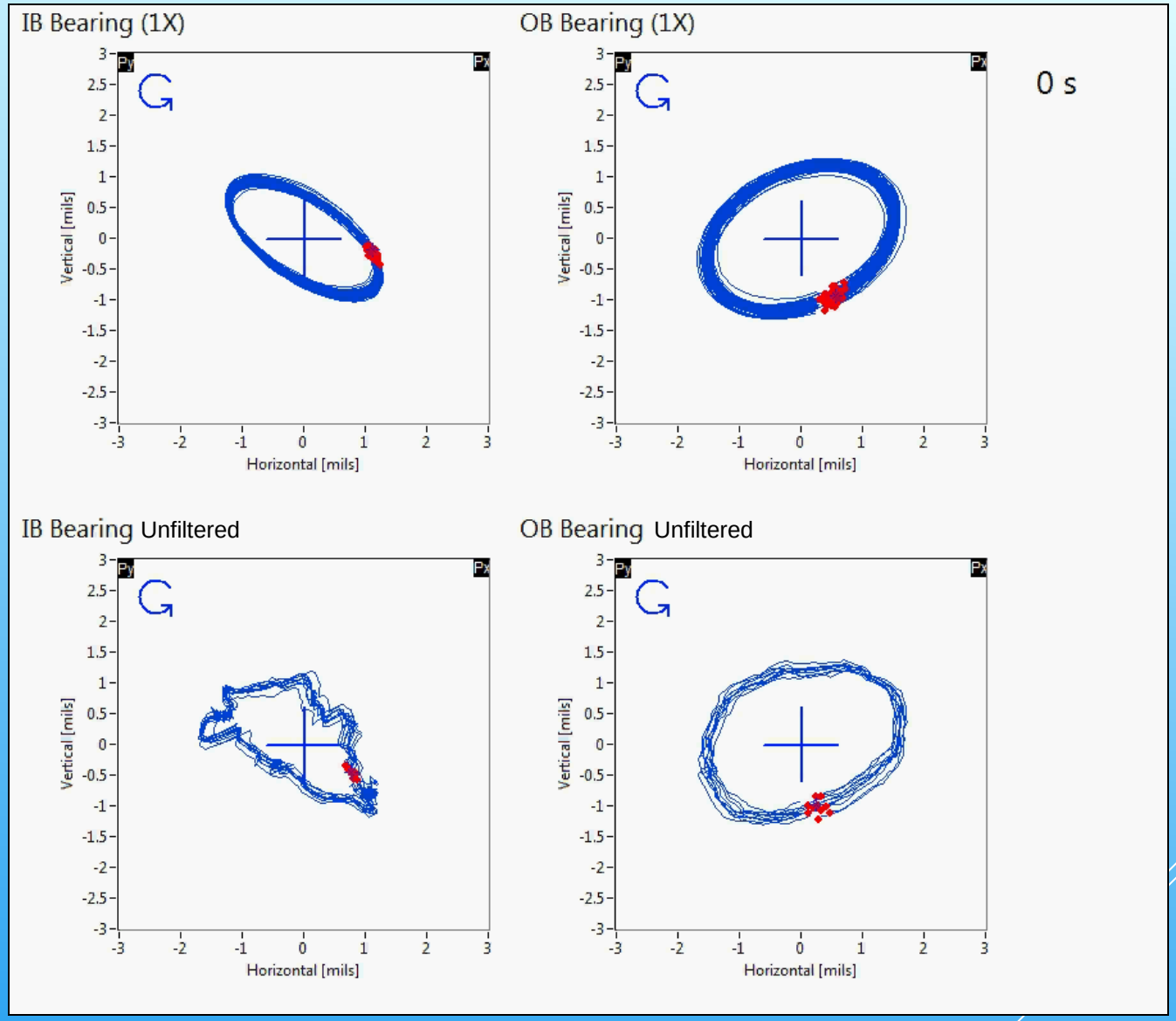
Vibration Testing – Shaft IBB Vibration Trend



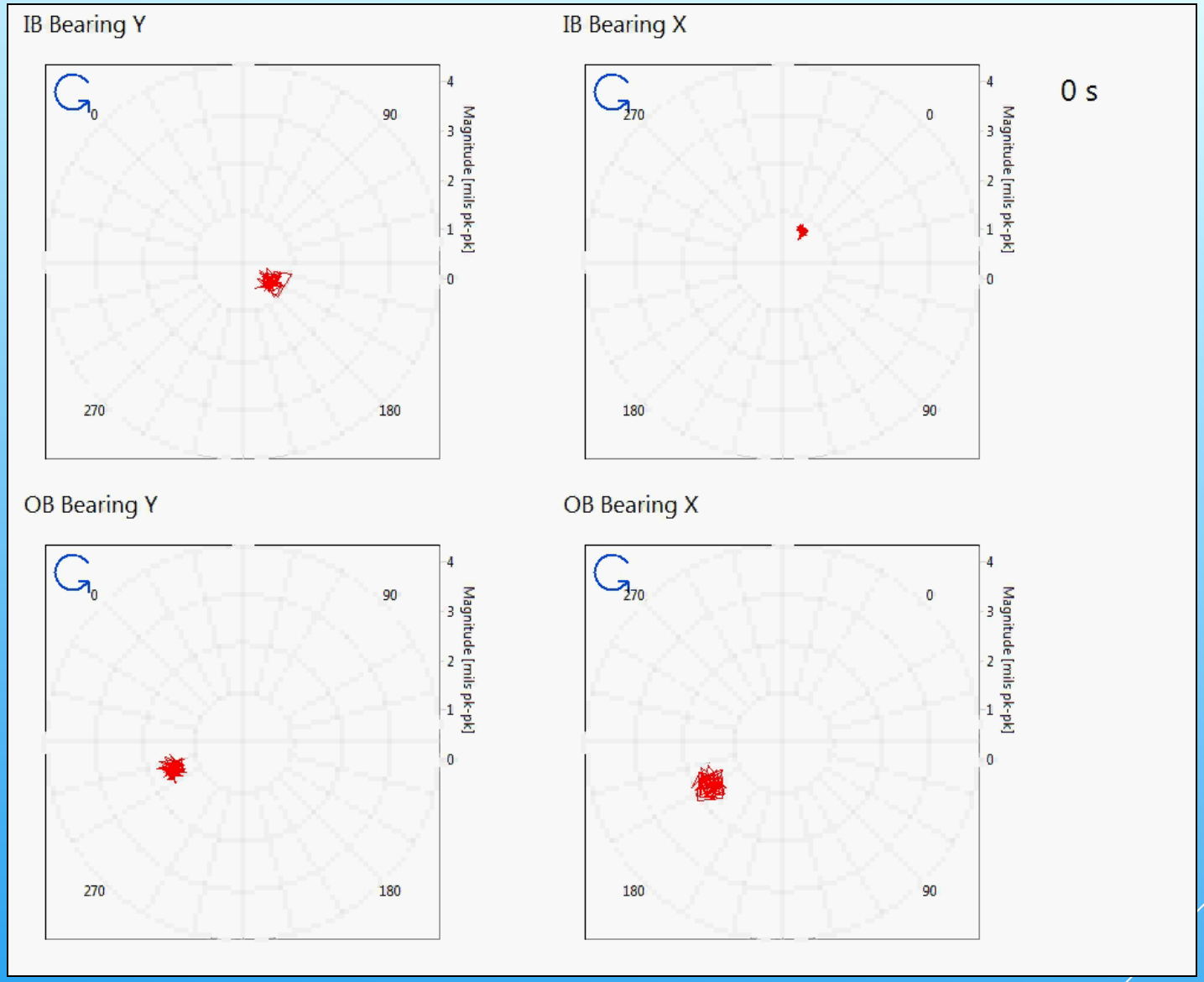
Vibration Testing – Speed Trend



Vibration Testing – Orbit Plots



Vibration Testing – Polar Plots



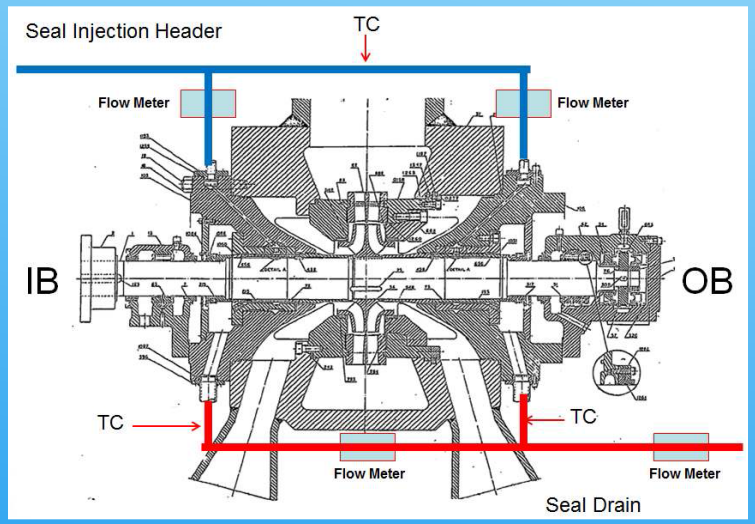
Note:
These plotted points shift in amplitude and phase, following a circular pattern (see animation).

Vibration Testing – Preliminary Conclusions

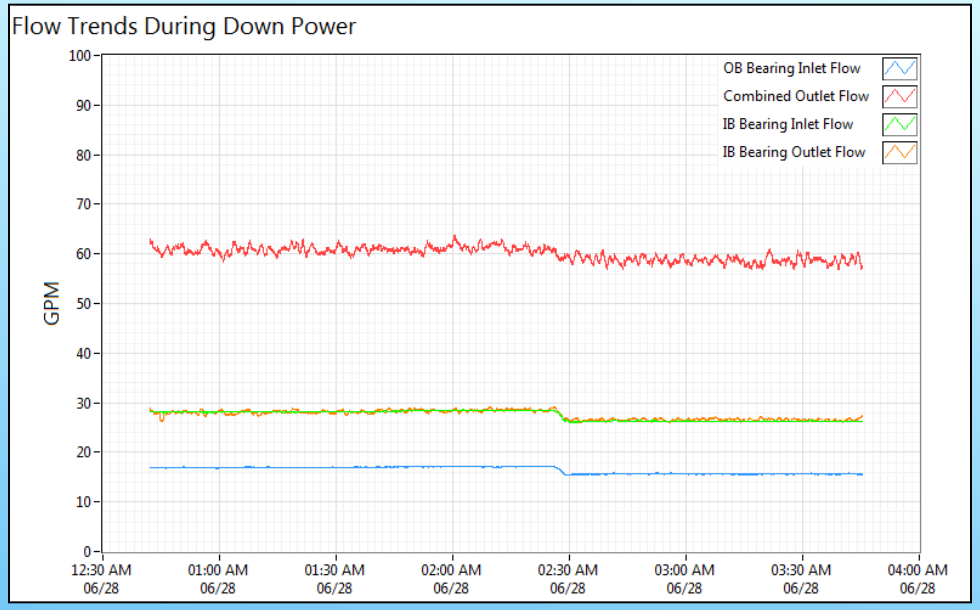
- ***Morton-like Effect:*** static imbalance vector (i.e. the steady average mechanical imbalance) combined with a secondary vector (non-constant phase imbalance vector). The secondary (cycling) imbalance vector is produced from a thermal distortion of the shaft in which a localized high temperature area of the shaft travels the full circumference with every vibration swell. The imbalance vectors behaving in this way are what cause the vibration level cyclic trends such as those experienced by the pump.
- This phenomenon is typically caused by either a light rub or a “near rub” (boundary lubrication at the “pinch point”) in a synchronously whirling shaft leading to a “hot spot” on the “heavy side” of the shaft that leads to thermal bow of the shaft, changing the “heavy side” location. Such a condition can occur in either a bearing or a seal, but in the case of a bearing the vibration cycles are typically longer (on the order of 5 to 10 minutes) than observed in the present case.

Vibration Testing – Preliminary Conclusions

- Morton Effect is dependent on the thermal state, fluid close internal clearances, and fluid dynamics within the seal cavities of the pump. However, Morton Effect may be affected by changes in pump speed, seal water injection temperature, and flow rate.
- Plant personnel tried different ways to eliminate this phenomenon and detected a strong influence by the condensate seal water temperature (seasonal) or by changing the seal water injection flow. However, the results were not always consistent and sometime without any effect.

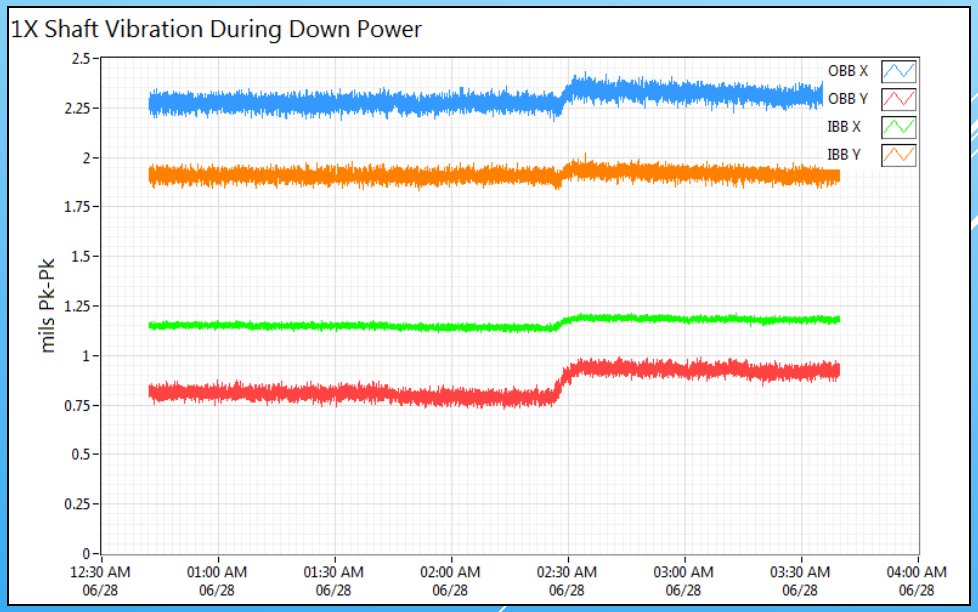


Seal Water Injection Testing

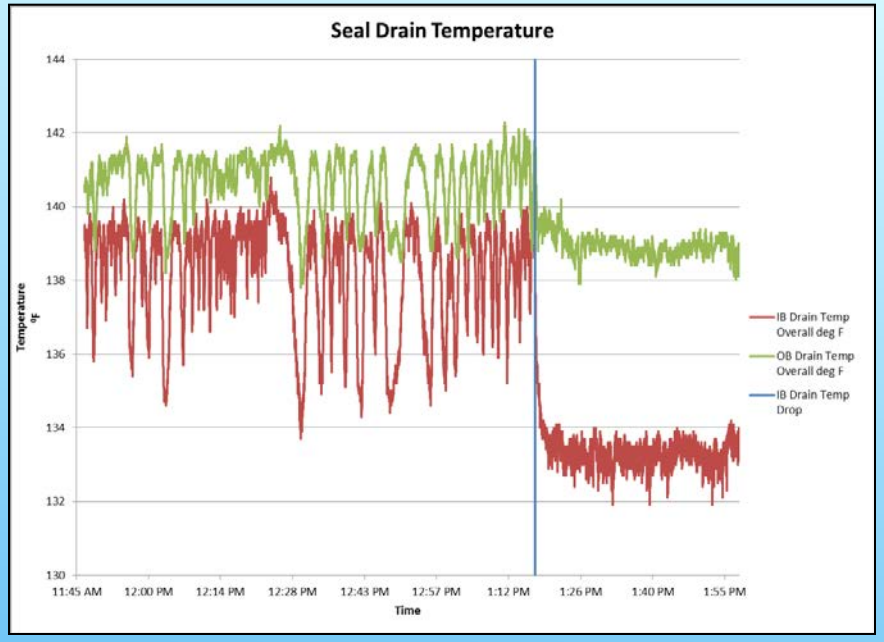


Morton-like Effect not detected after slight reduction of seal water injection flow and increment of drain temperature.

June 2012

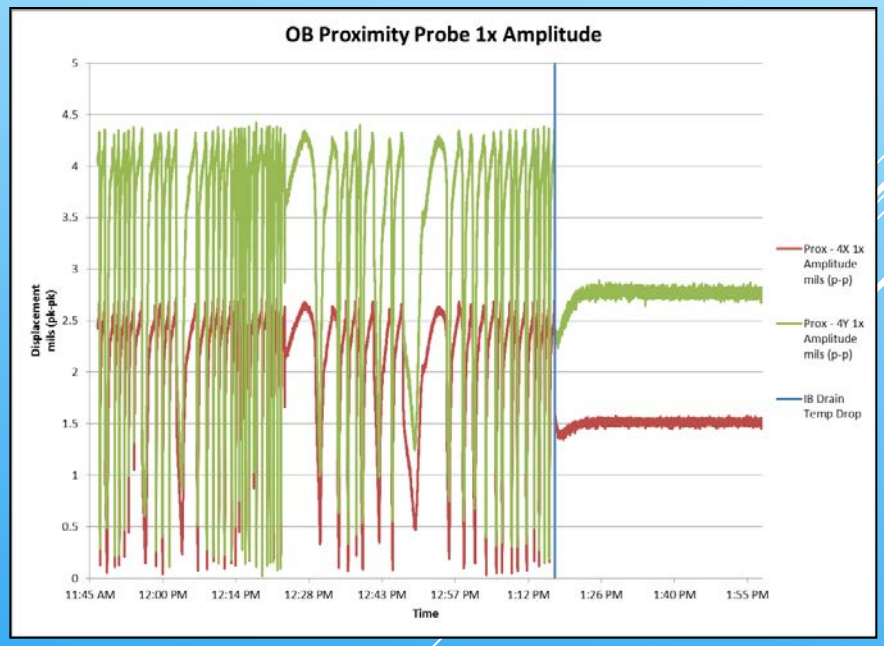


Seal Water Injection Testing

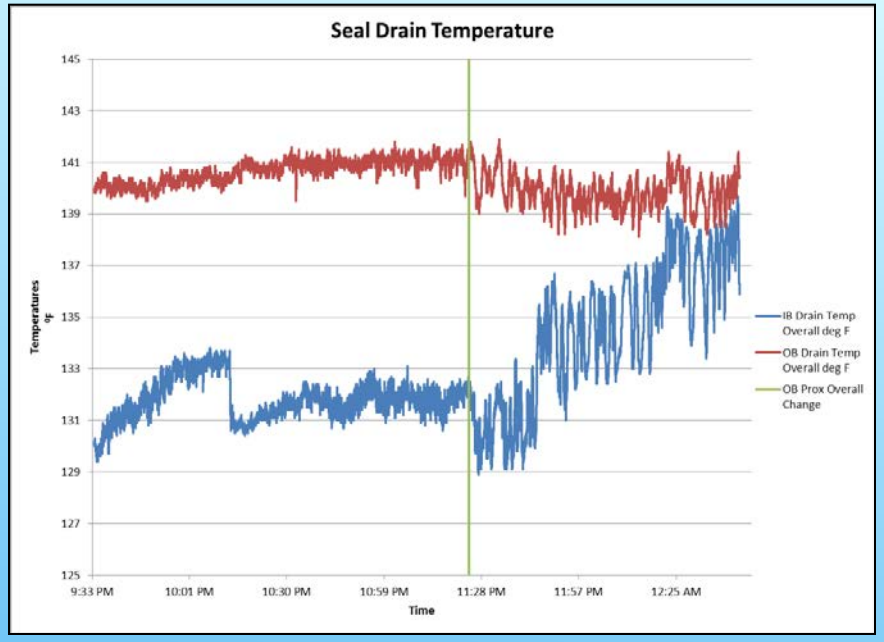


End of Morton-like Effect after increasing seal water injection flow and reducing drain temperature.

August 2012

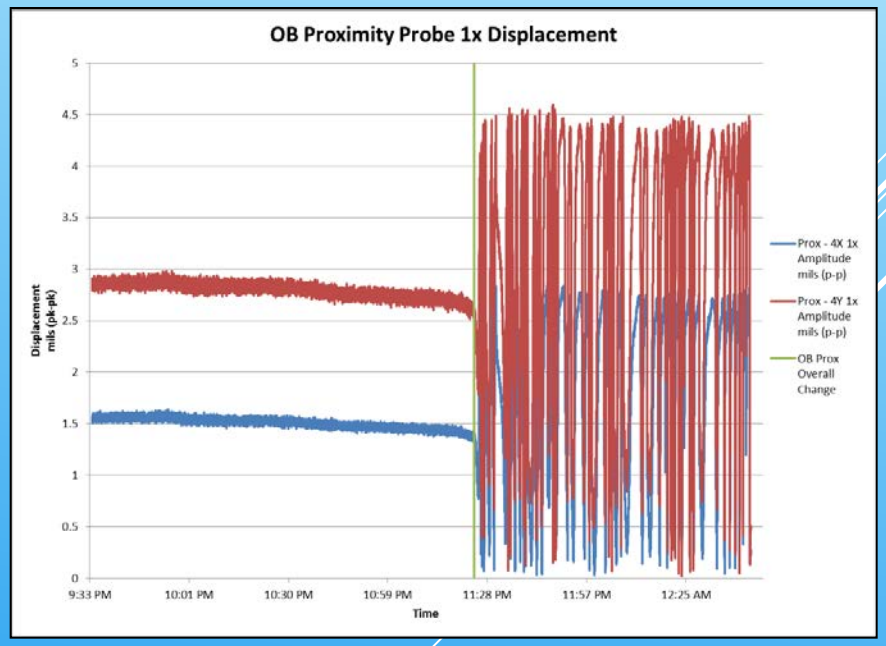


Seal Water Injection Testing

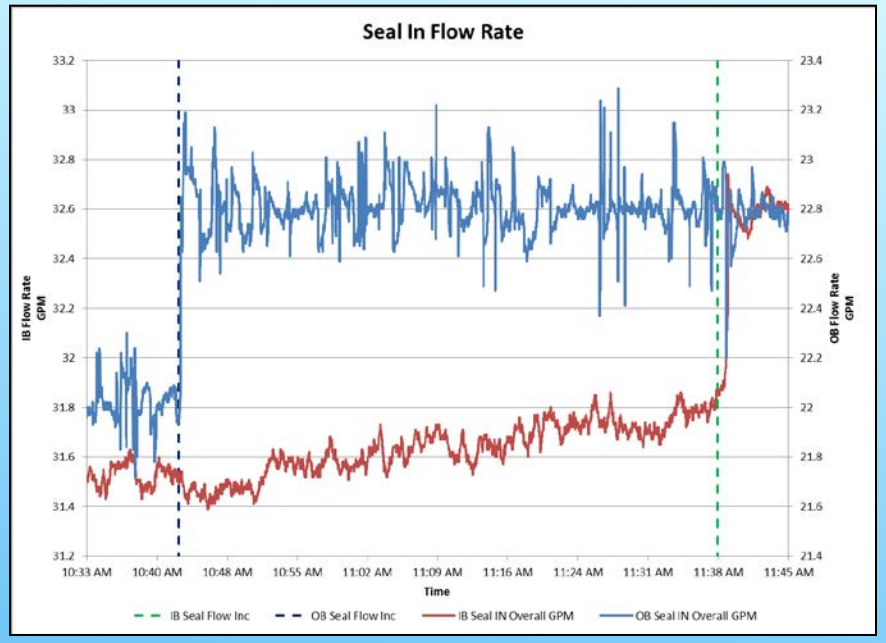


Start of Morton-like Effect after slight reduction of seal water injection flow and increasing drain temperature.

August 2012

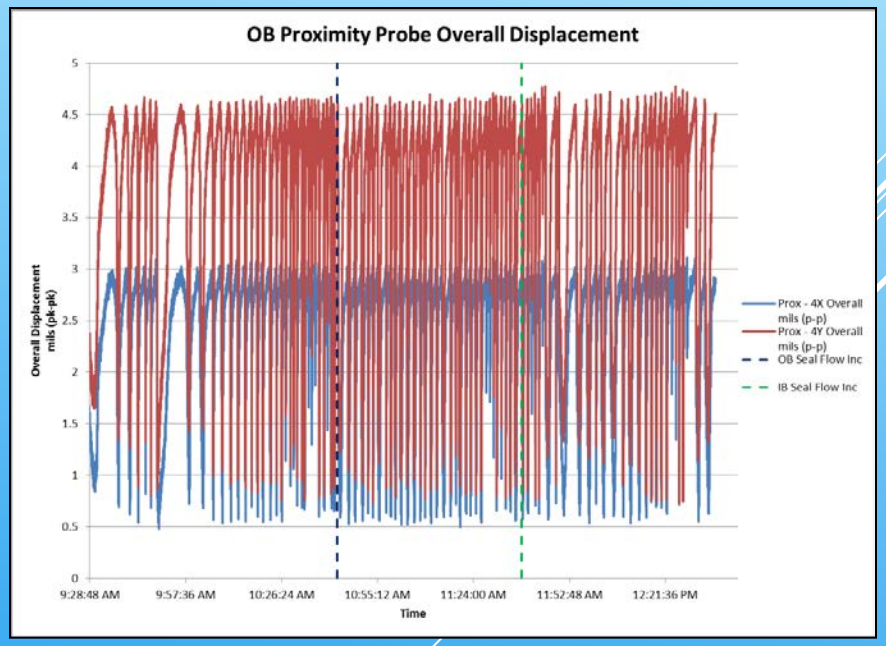


Seal Water Injection Testing



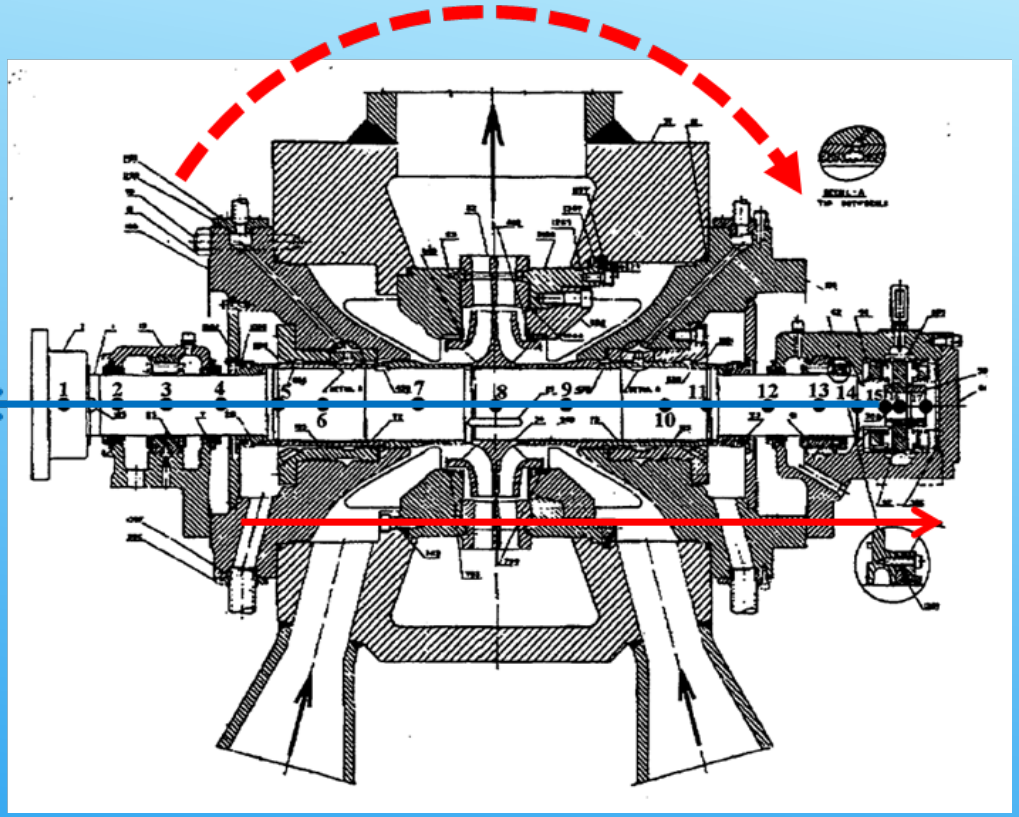
No effect on Morton-like Effect after seal water injection flow increased and reduced drain temperature.

August 2012



Conclusions

- After a thorough investigation between site personnel and MSI, it was concluded that the root cause of the Morton-like Effect was due to a casing distortion that was altering the internal clearances between the shaft and the long seal sleeve.



Conclusions

- The torque applied to the hold-down bolts to the pedestals at the outboard and inboard end of the pump was approximately 4,400 ft-lb. The required torque, based on the OEM manual, is 1,800 ft-lb at the inboard end and 550 ft-lb at the outboard end. This would allow the casing to grow axially while it reaches the thermal equilibrium.
- Once the torque of the hold-down bolts were corrected, the Morton-like Effect vibration was eliminated.