

Dramatic Vibration Improvement due to Ring-Section Pump Foundation Repair Based on ODS in a Power Plant

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By:

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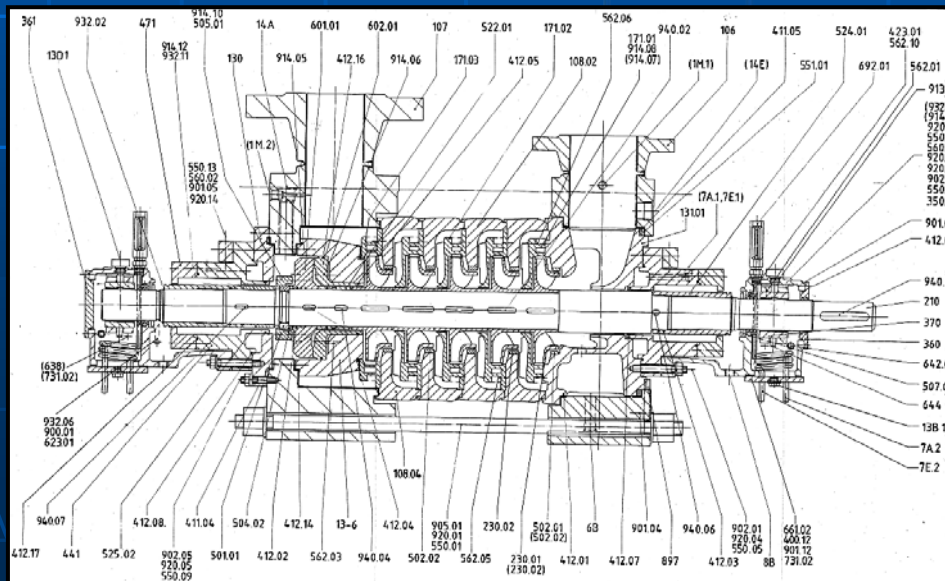
Constellation Energy

Mark Fry

Hydro East, Inc.

History

- Three multistage ring-section BFP's installed in 1991 at Panther Creek Energy Waste Coal-Fired Power Plant (83 MW). Pumps driven by two-pole induction motors (3,585 rpm or 59.8 Hz).
- In 2007, Pump #2 was removed for maintenance service after nine years of continuous operation. Normal vibration below 0.10 in/s peak @ 1x rpm.



History

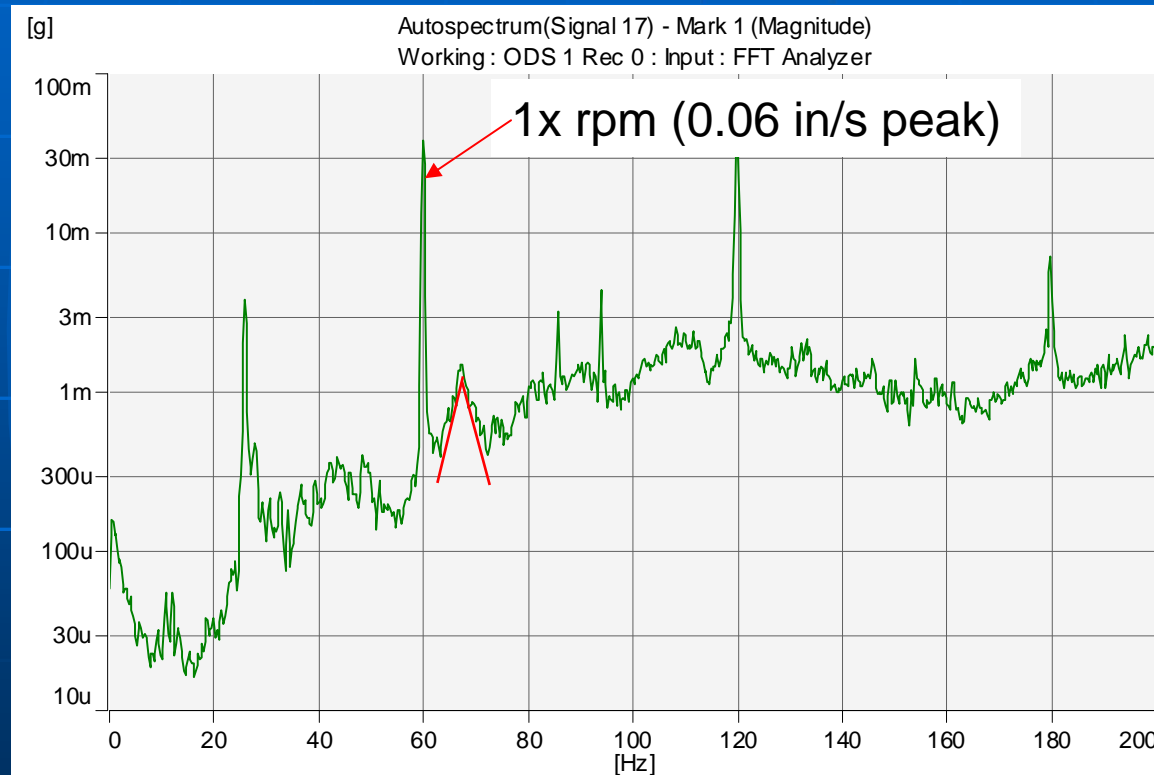
- **Detected high vibration at the outboard bearing housing in the horizontal direction. Gradual vibration increment over time (from 0.06 in/s pk to 0.25 and 0.35 in/s pk).**
- **Over one year period, modifications were implemented to improve the erratic vibration amplitude:**
 - **Motor and pump pedestal pads machined to eliminate alignment shims under pump.**
 - **Spare rotor assembly was balanced with 1W/N spec. and installed in the pump.**
 - **Sleeve bearings were replaced due to high bearing temperature.**

Vibration Testing

- **Monitoring test during transient and steady operation to monitor the vibration amplitude, natural frequencies, and phase angle.**
- **Experimental Modal Analysis (EMA) test to determine the natural frequencies of the pump structure and the rotor system.**
- **Operating Deflection Shape (ODS) testing during steady operation.**

Vibration Monitoring

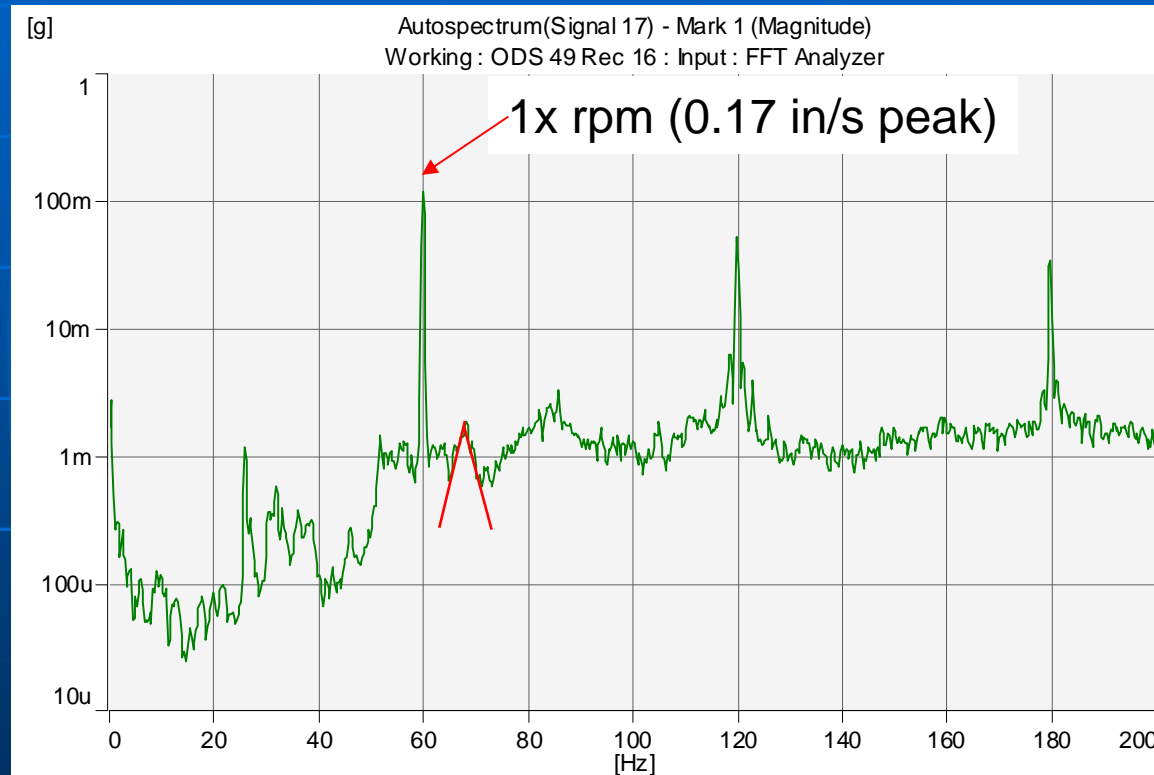
Pump #1 Typical Spectrum OBB in the Horizontal Direction



Natural frequency at 67.3 Hz (12.6% above 1x rpm)

Vibration Monitoring

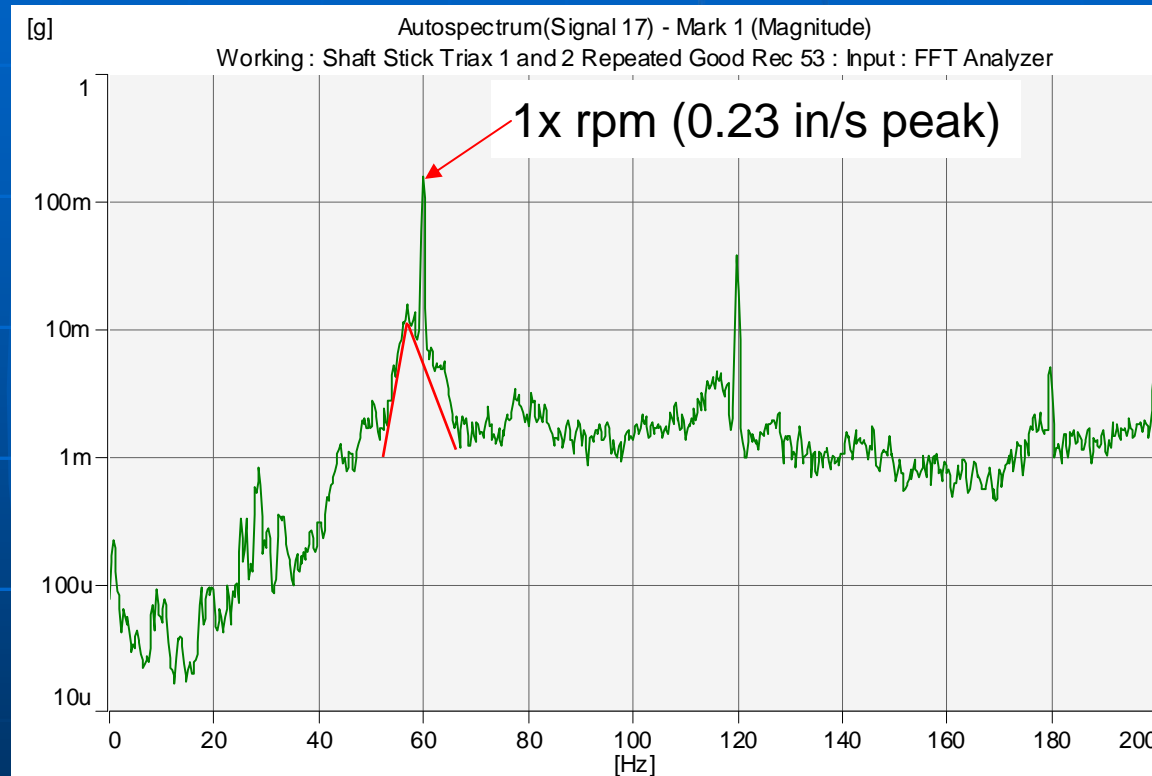
Pump #3 Typical Spectrum OBB in the Horizontal Direction



Natural frequency at 68 Hz (13.8% above 1x rpm)

Vibration Monitoring

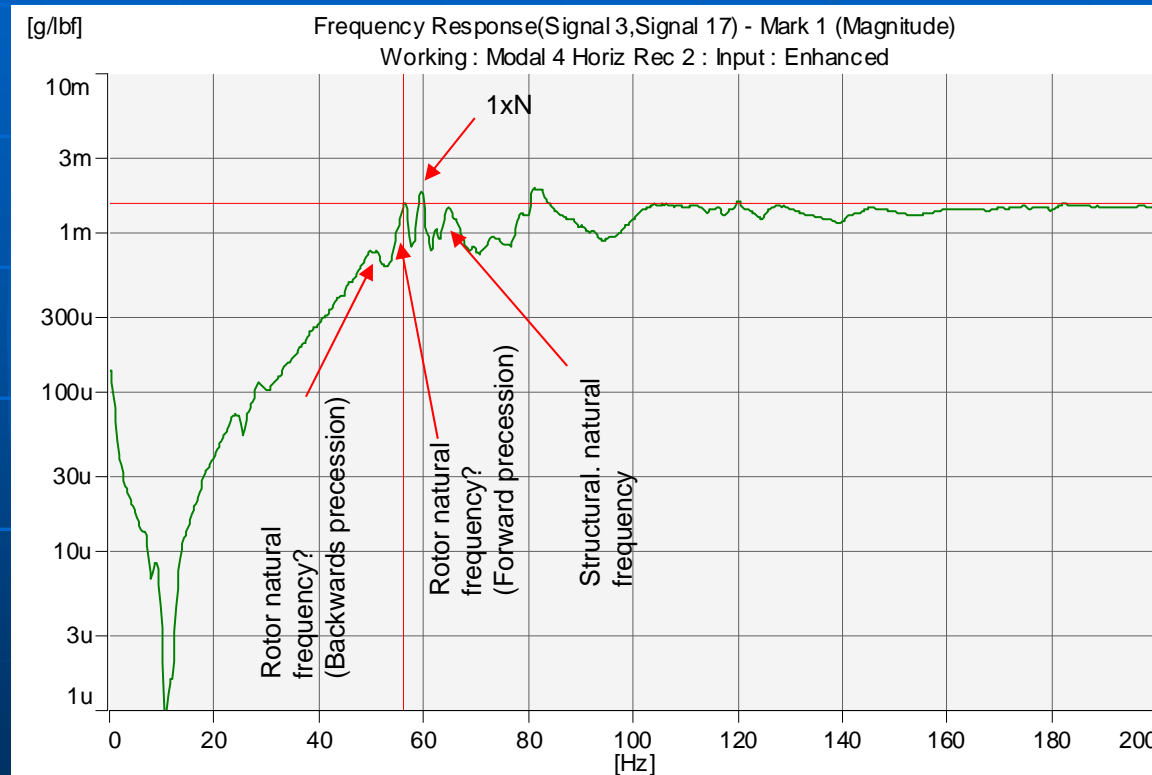
Pump #2 Typical Spectrum OBB in the Horizontal Direction



Closest Natural frequency at 56.8 Hz (5% below 1x rpm)

Vibration EMA Test

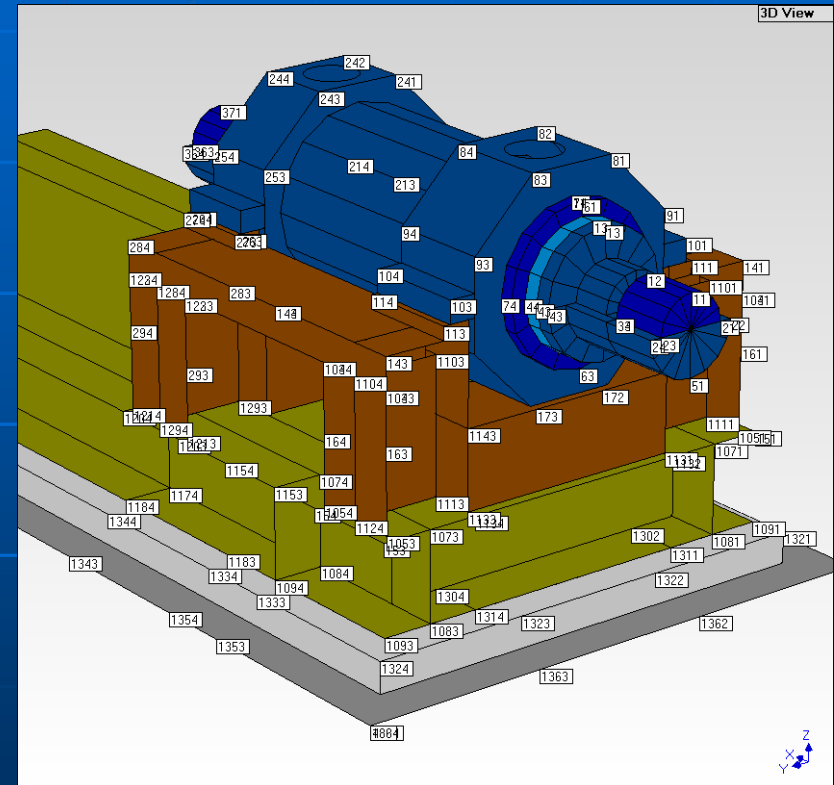
Pump #2 Modal (Operating) Spectrum in the Horizontal Direction at the Pump OBB Housing



Closest Natural frequency at 56.8 Hz (5% below 1x rpm)

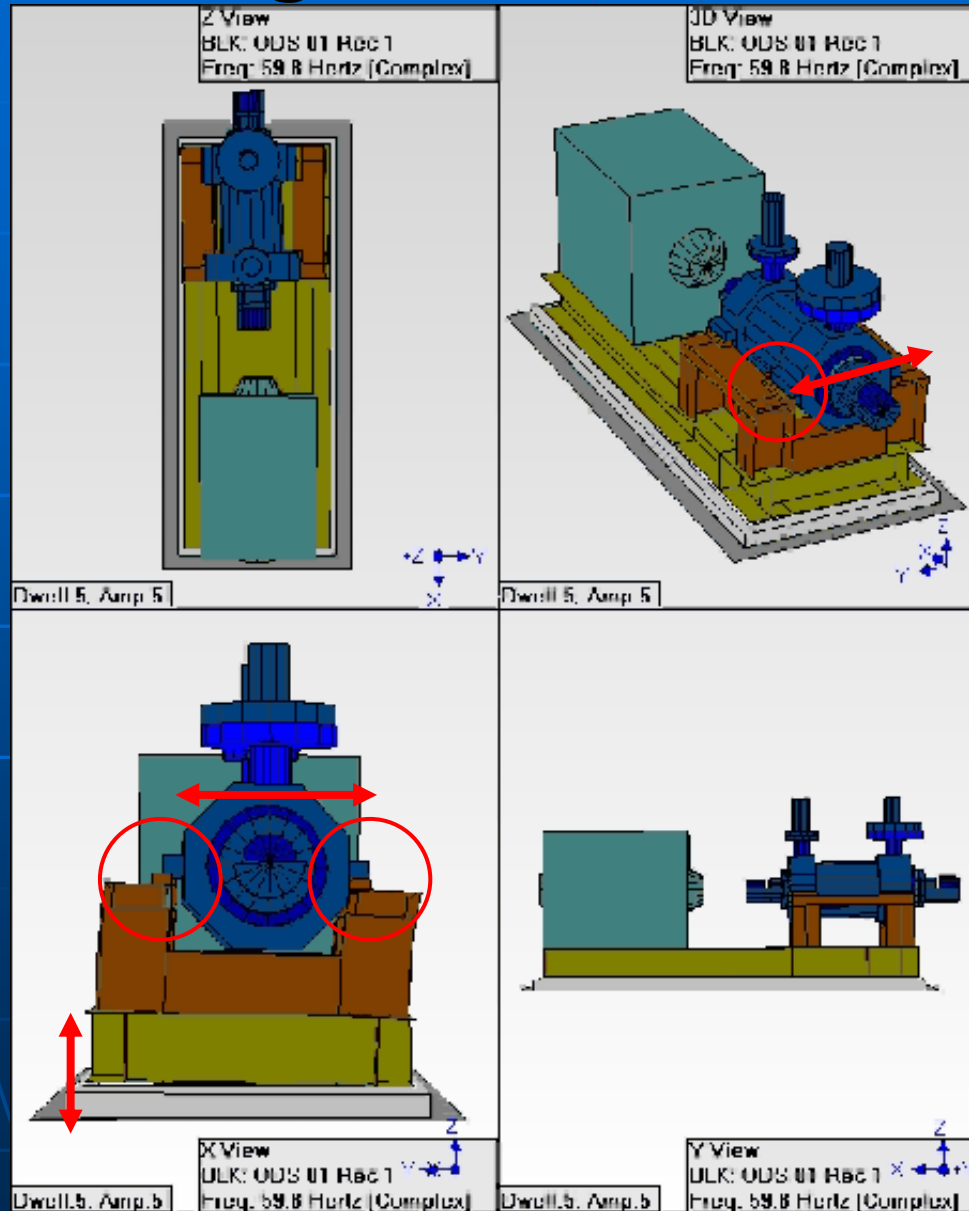
Operating Deflection Shape

- Natural excitation signature of the pump structure.
- Over 850 vibration measurements.
- Data base of amplitude vs. frequency and phase angle.
- 3-D CAD model assigning motion to each individual vibration data point.
- Create animations of the pump



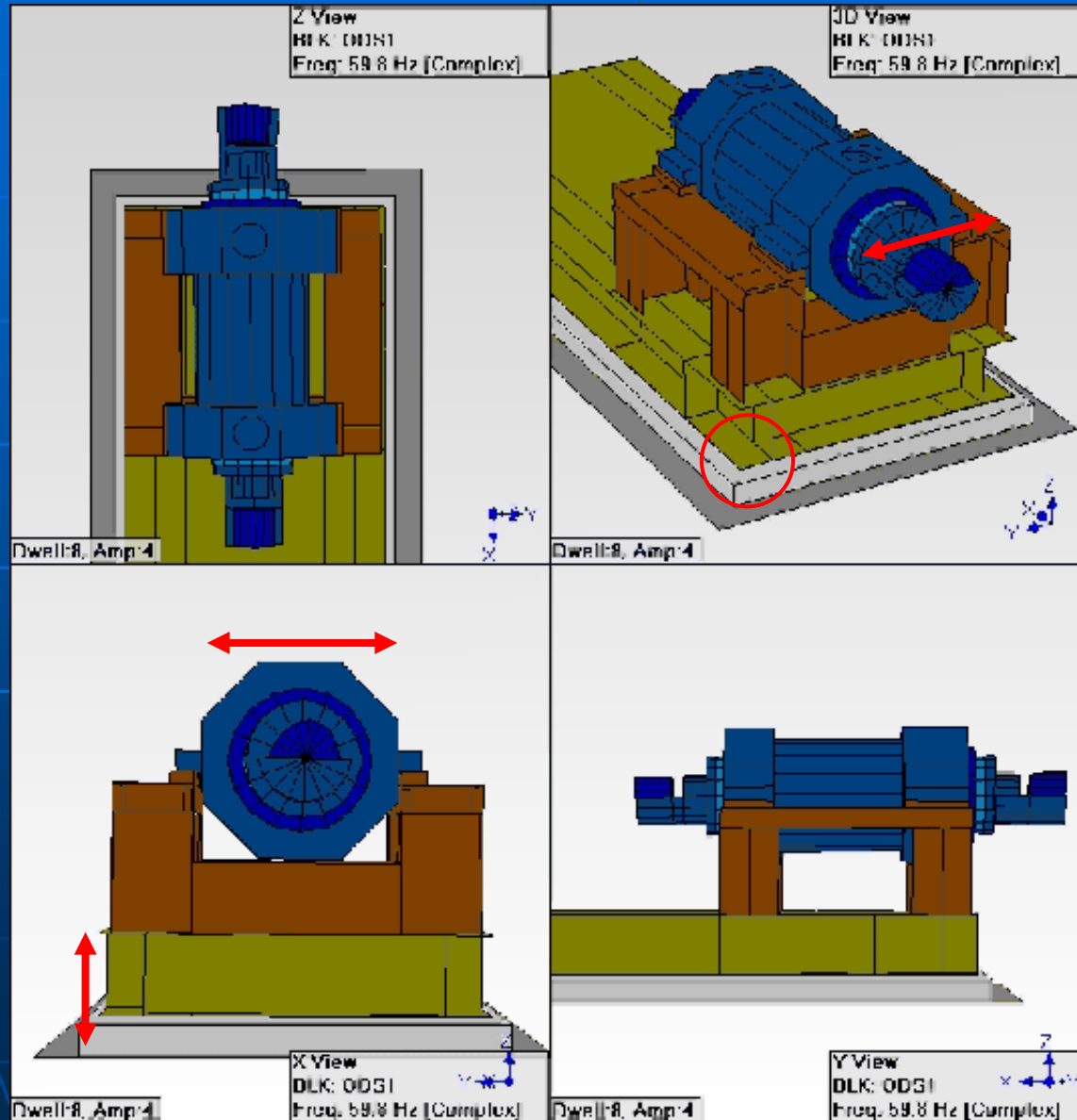
Operating Deflection Shape

Baseline
data
Pump #2
@ 1x rpm



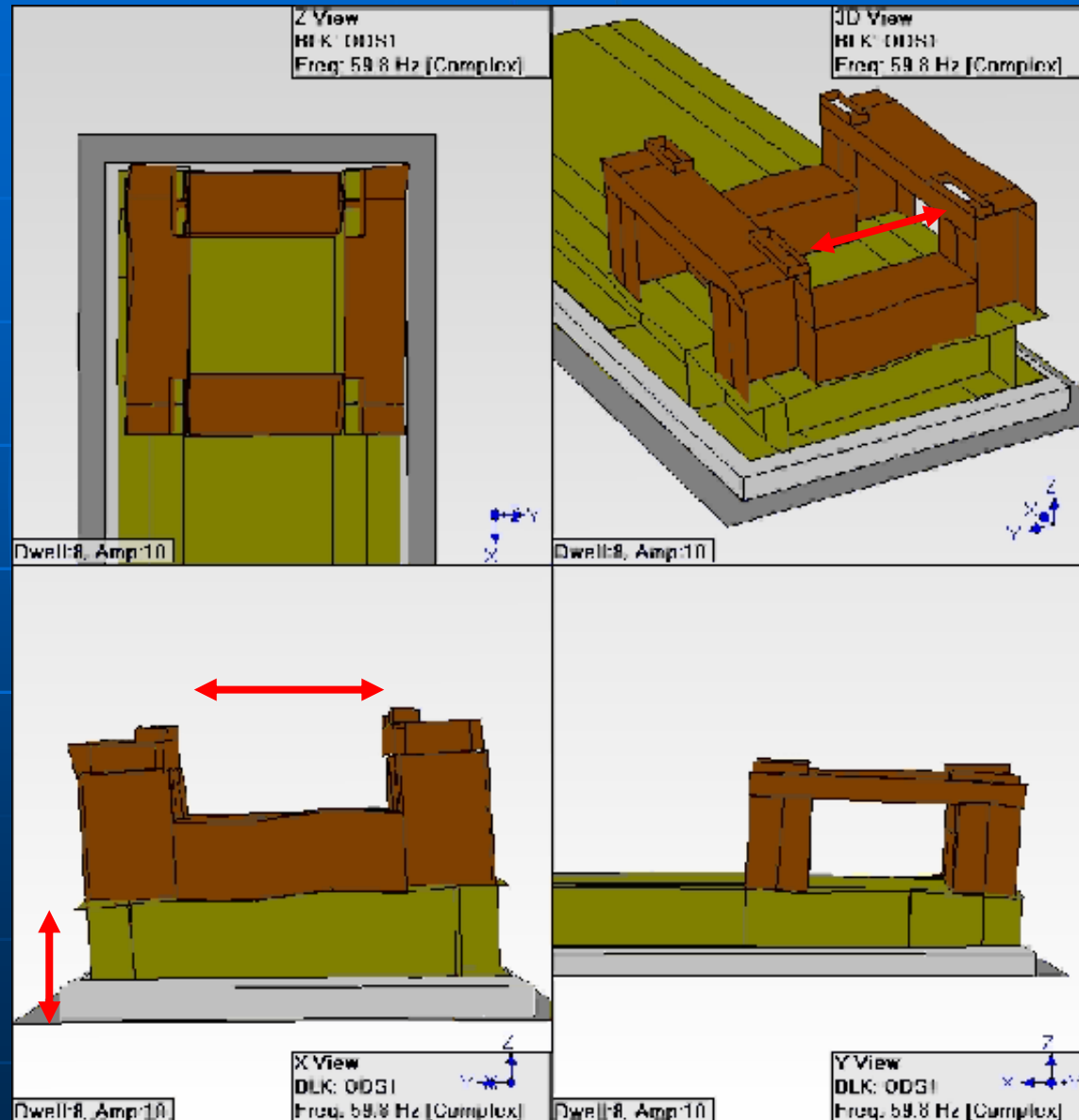
Operating Deflection Shape

Pump #2 @
1x rpm after
OB feet
bolts
tightened

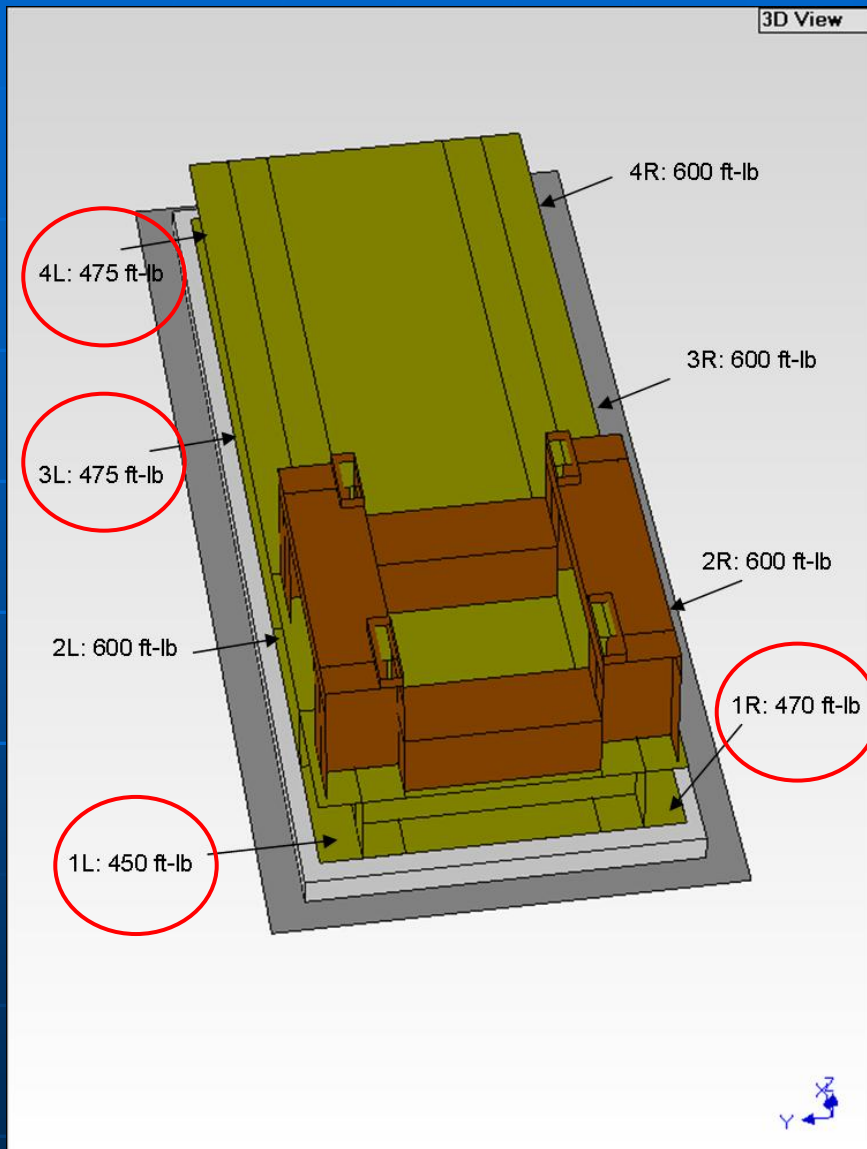


Operating Deflection Shape

Pump #2 @
1x rpm after
OB feet
bolts
tightened



Operating Deflection Shape

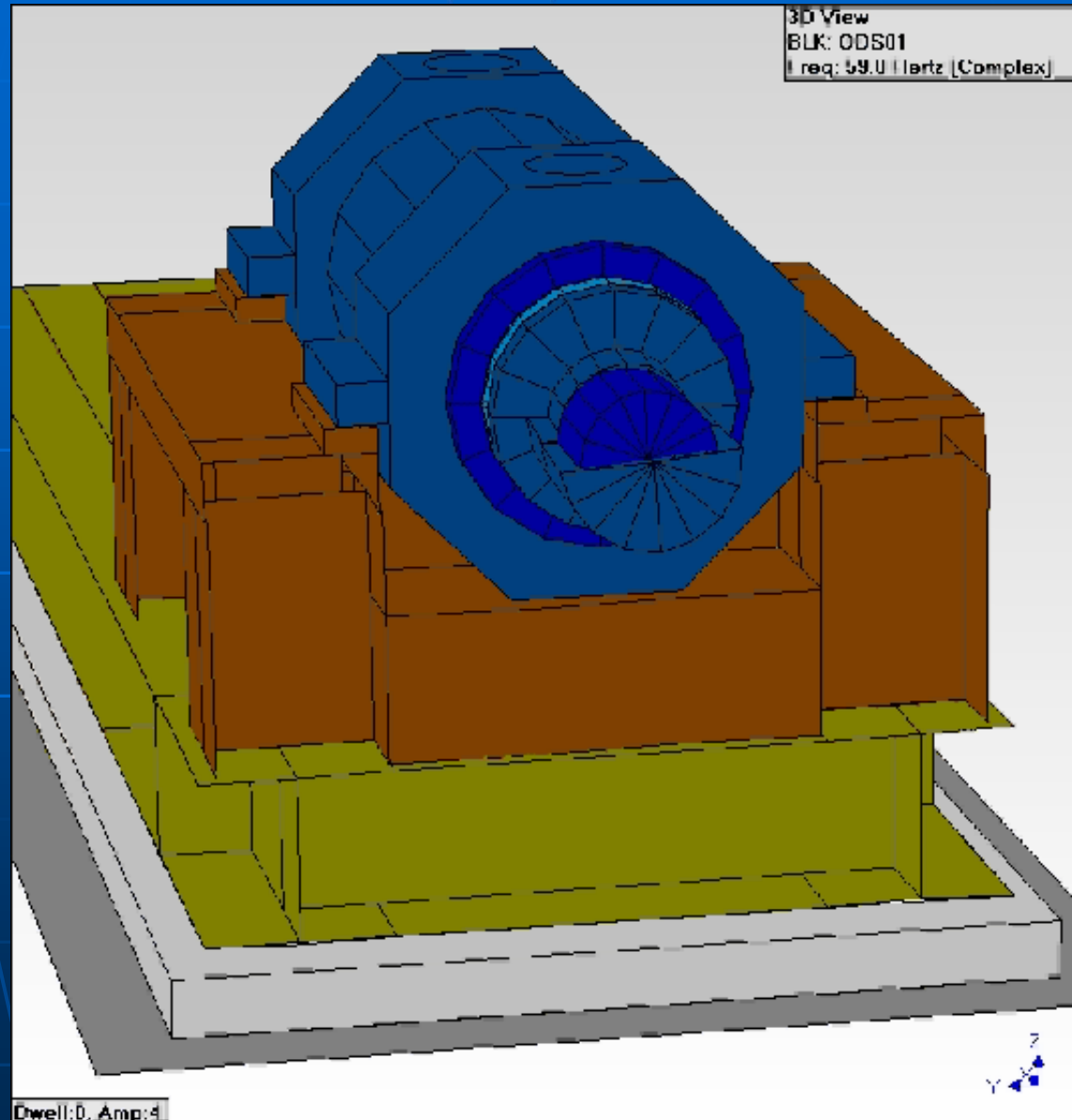


Actions Taken:

- All J-bolts of the baseplate torqued up to 600 ft-lb.
- Pump IB feet bolts torqued up to 1000 ft-lb.
- Dowel pin and holes cleaned up and drove pins in tight.
- Pump OB feet tightened after full warm-up condition

Operating Deflection Shape

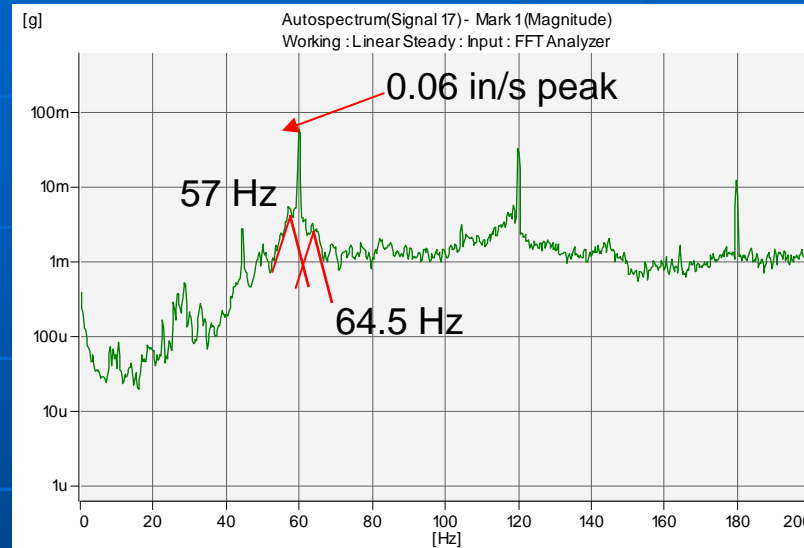
**Pump #2 @
1x rpm after
OB feet bolts
and
baseplate
anchor bolts
tightened**



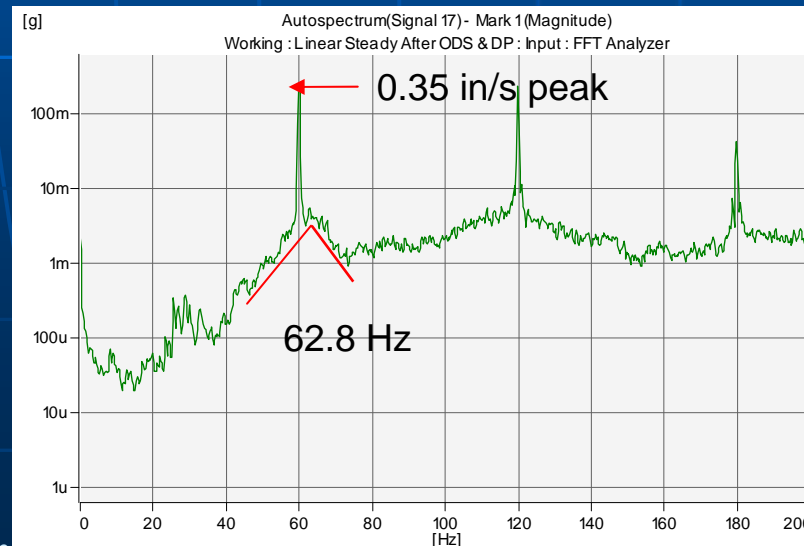
Vibration Monitoring

Pump #2 Typical Spectrum OBB in the Horizontal Direction

Time: 9:50

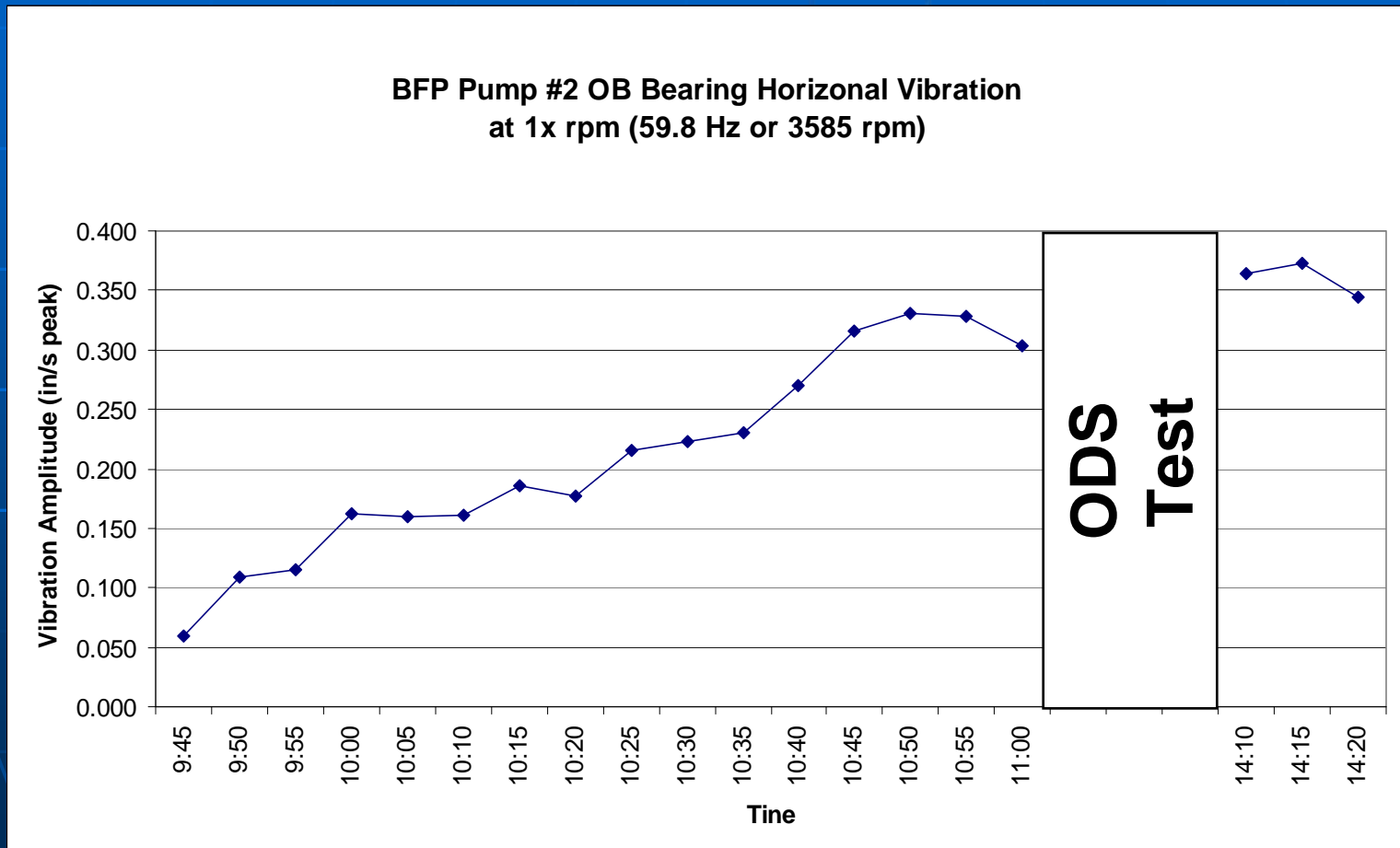


Time: 14:04



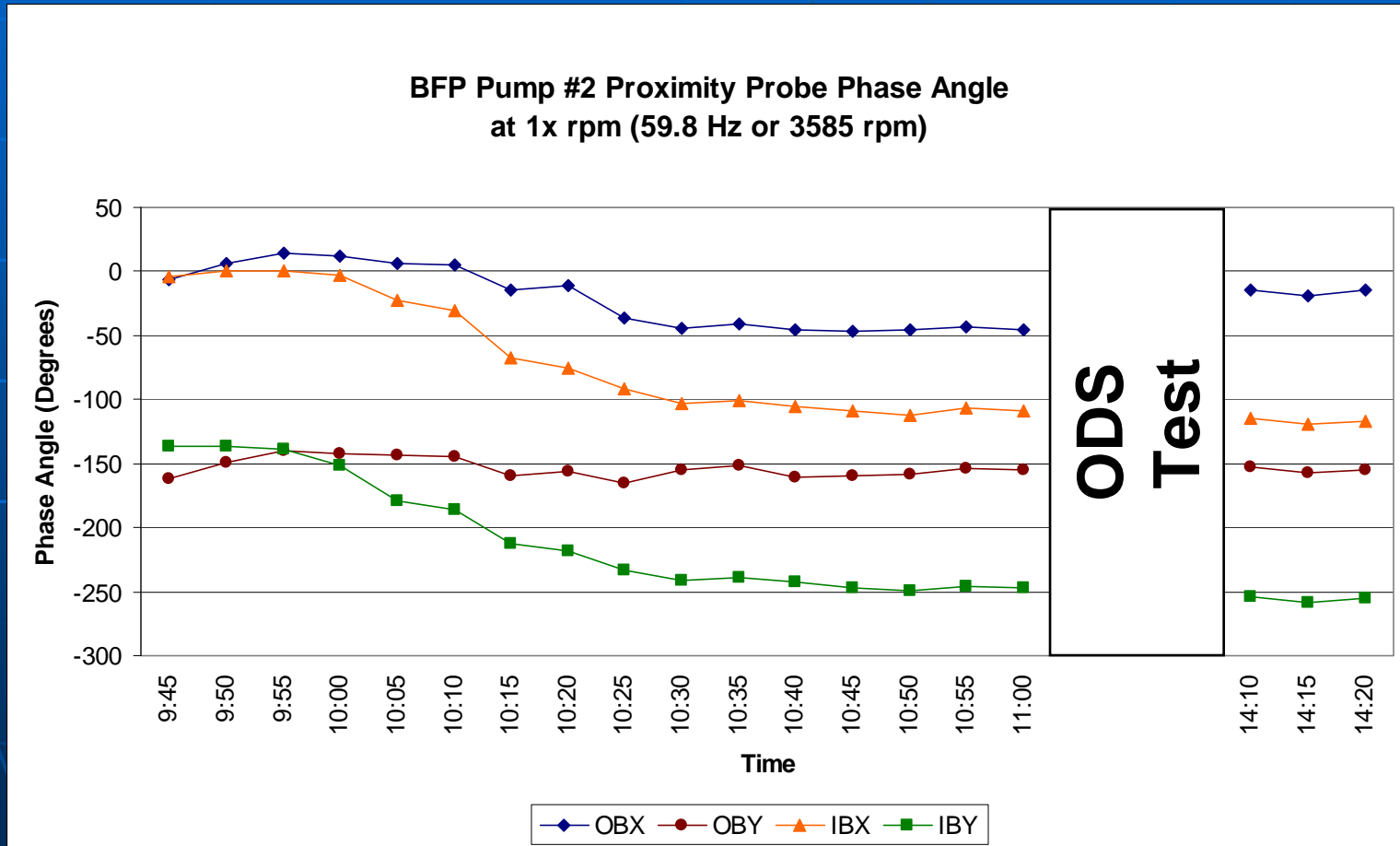
Vibration Monitoring

Pump #2 OBB Housing Vibration Trend in the Horizontal Direction



Vibration Monitoring

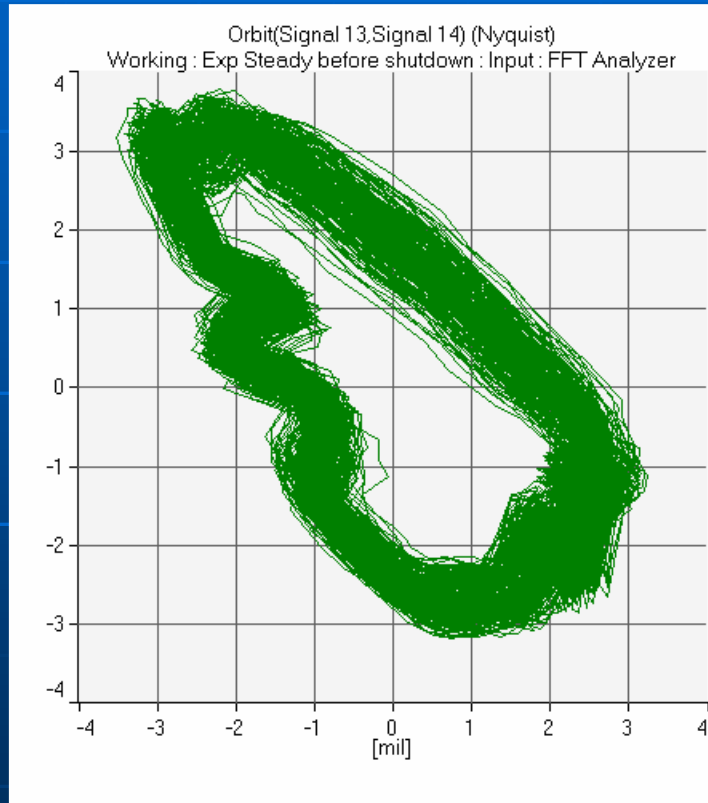
Pump #2 Proximity Probe Phase Angle Trend Plot



Vibration Monitoring

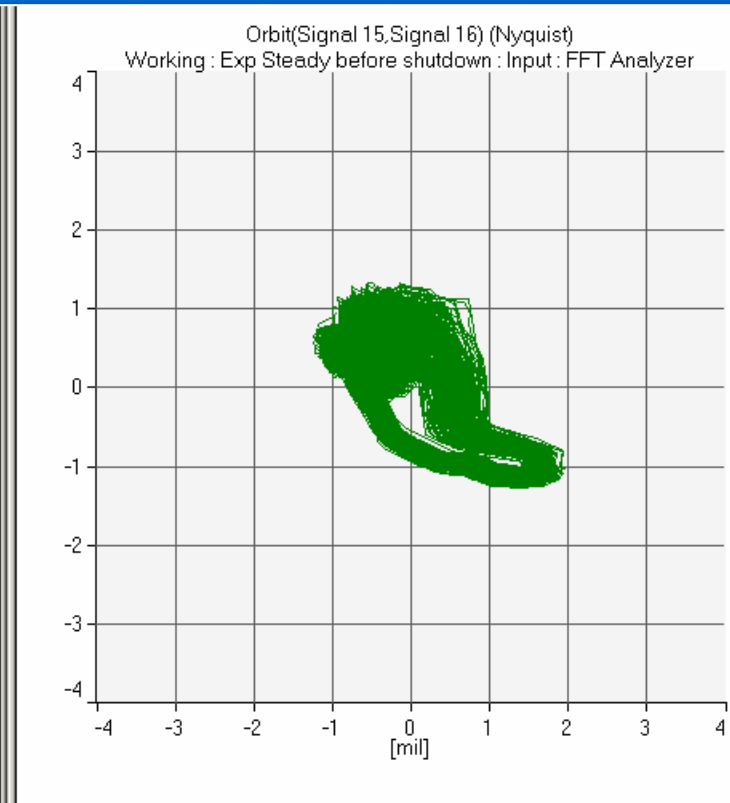
Pump #2 Shaft Orbits at 14:20 (4.5 hours after cold start up)

OBB



6.5 mils pk-pk

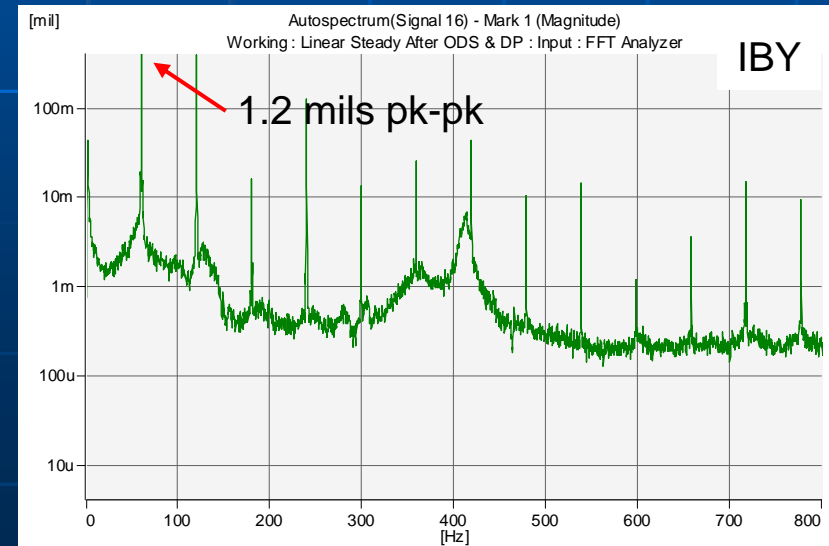
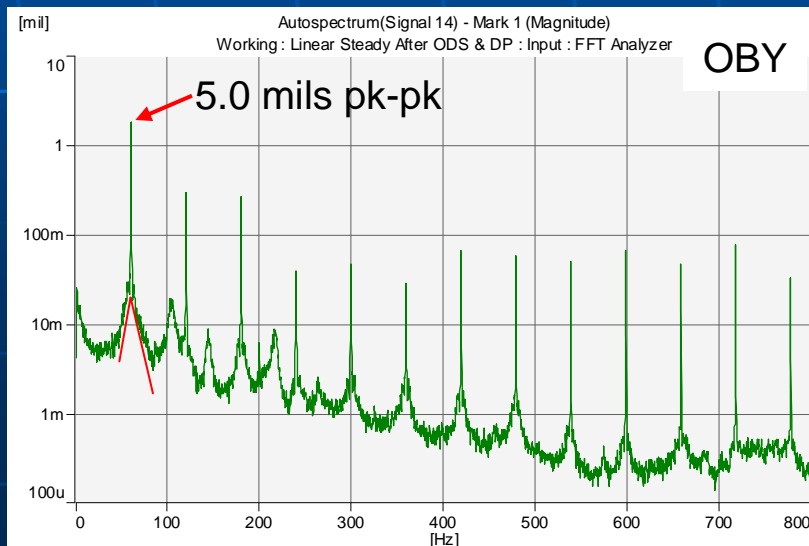
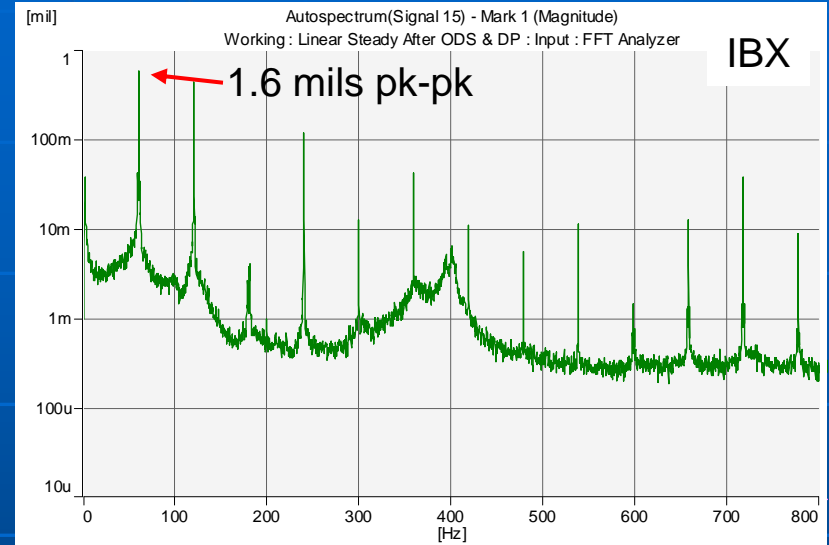
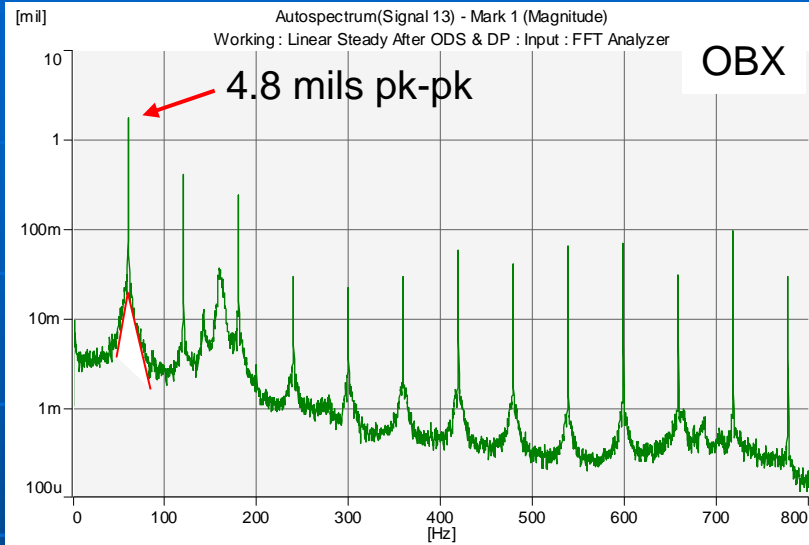
IBB



2.5 to 3.0 mils pk-pk

Vibration Monitoring

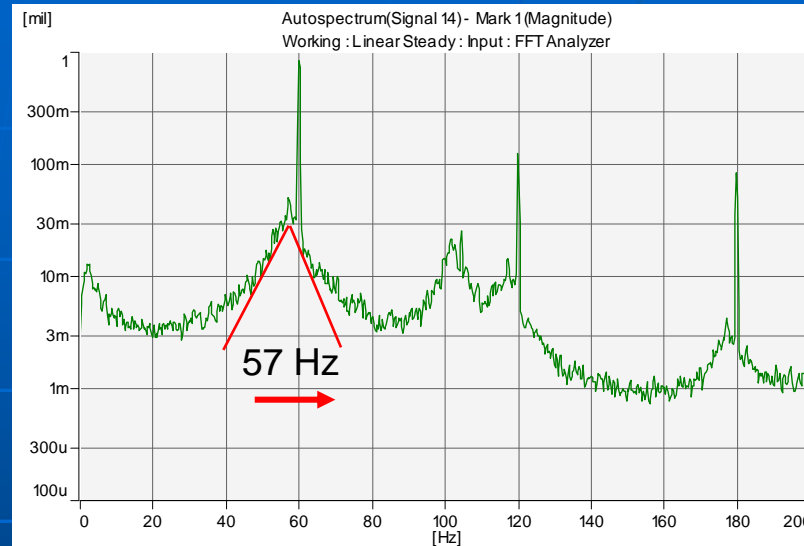
Pump #2 Shaft Spectra at 14:20 (4.5 hours after cold start up)



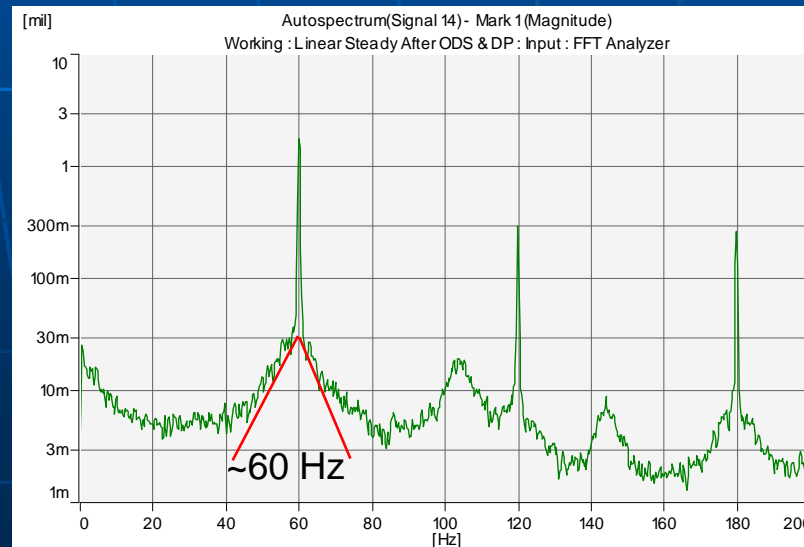
Vibration Monitoring

Pump #2 Shaft Proximity Probe - OBY Spectra

Time: 9:50



Time: 14:04

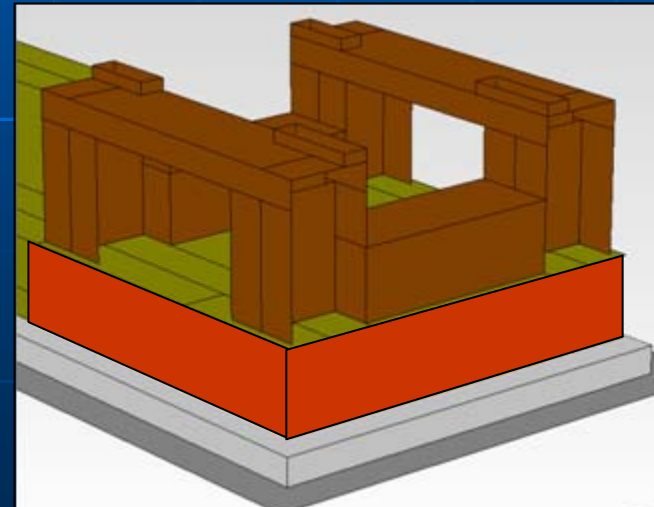
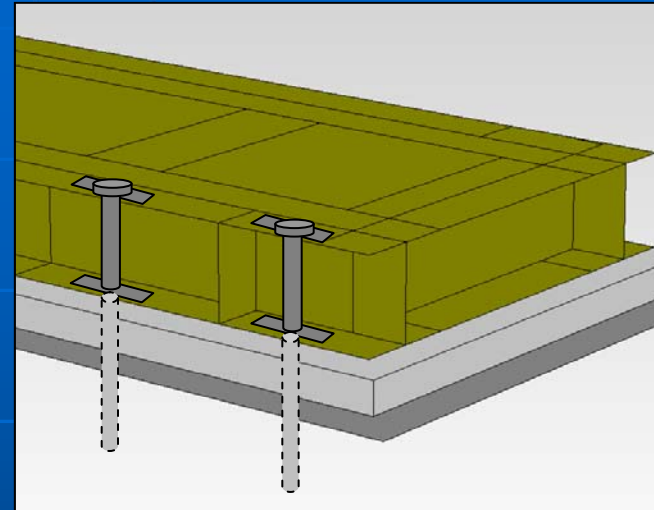


Preliminary Conclusions

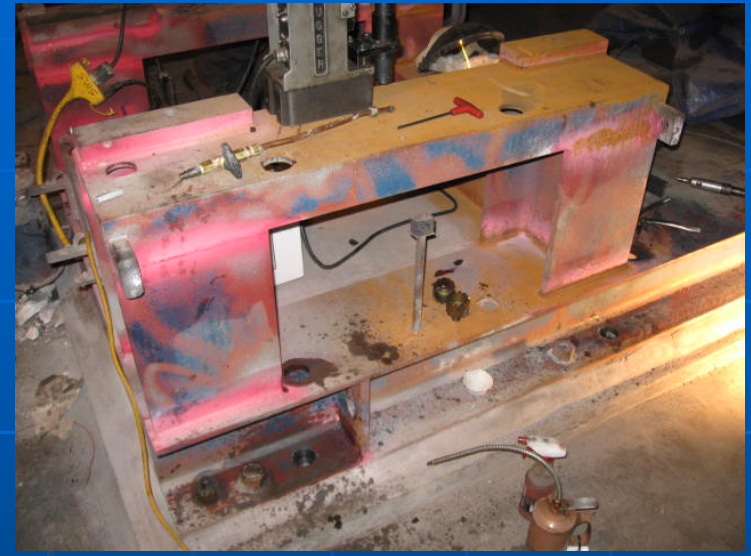
1. Excessive flexibility at the baseplate due to possible softness or delamination of the internal grout (Pump #2 moved 10x more than Pump #1).
2. OBB housing vibration increased almost 6 times in 4 hours of operation (from 0.06 in/s peak to 0.35 in/s peak @ 1x rpm), and 50% shaft vibration.
3. During the cold start up, 1x rpm spike located between two natural frequencies (57 Hz from the rotor lateral and 63.5 Hz from the structure). The structure became less stiff and reducing the damping of the system; therefore, the rotor natural frequency shifted upwards in the neighborhood of the running speed.
4. Shaft phase angle variation over time. (OBX -60 deg., OBY -20 deg., IBX -110 deg., and IBY -110 deg.)
5. Pumps #1 and #3 did not indicate rotor natural frequencies near the running speed. The lateral rocking mode was identified 13% above 1x rpm.

Proposed Recommendations

1. Inspect the welding areas of the pedestal and the baseplate for potential cracks.
2. As a short term fix, increase the stiffness of the baseplate.
3. As a long term fix, the baseplate should be re-grouted to assure rigid connection with the foundation and proper structural damping.

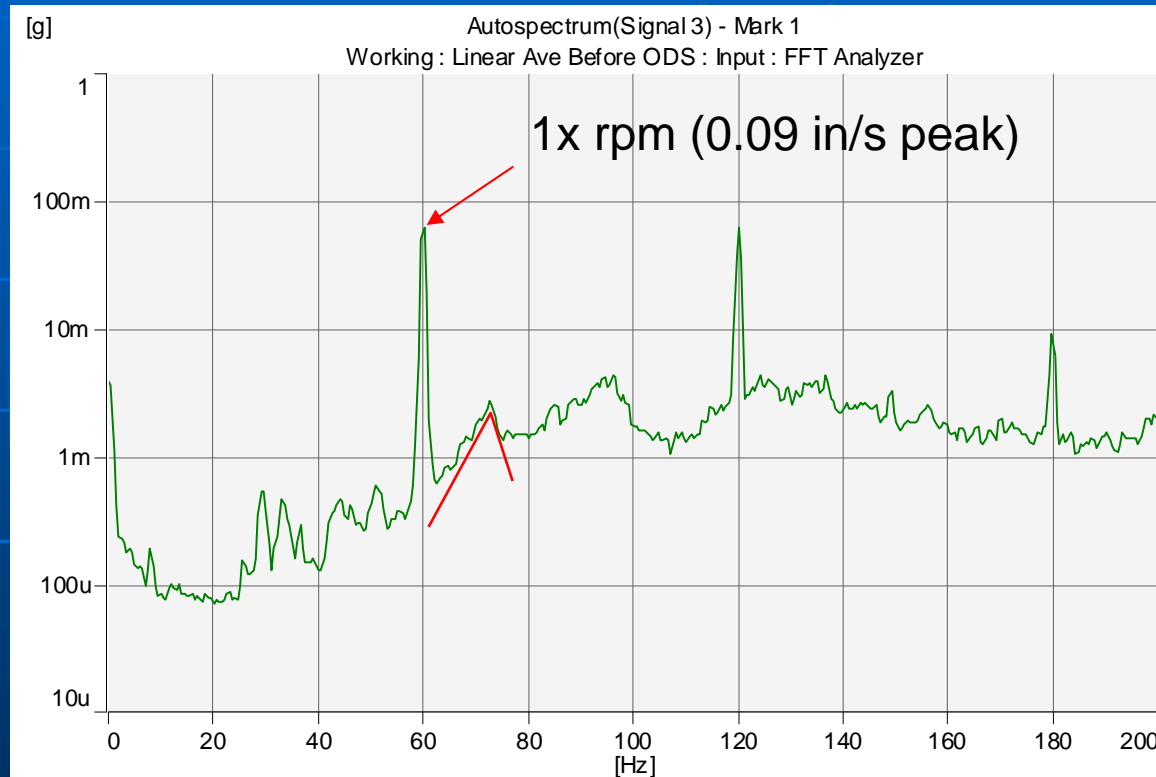


Pump Pedestal & Baseplate Modifications



Vibration Monitoring

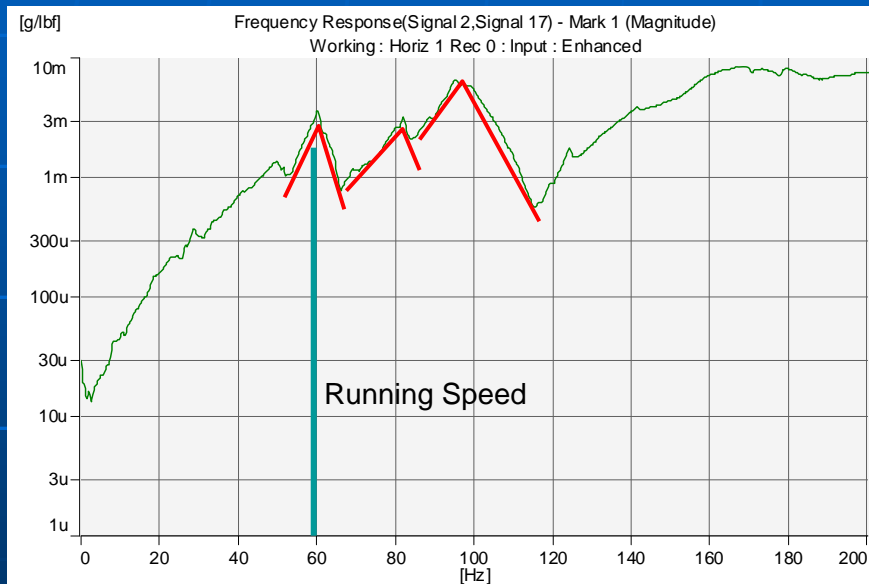
Pump #2 Typical Spectrum OBB in the Horizontal Direction After Implementing Modifications



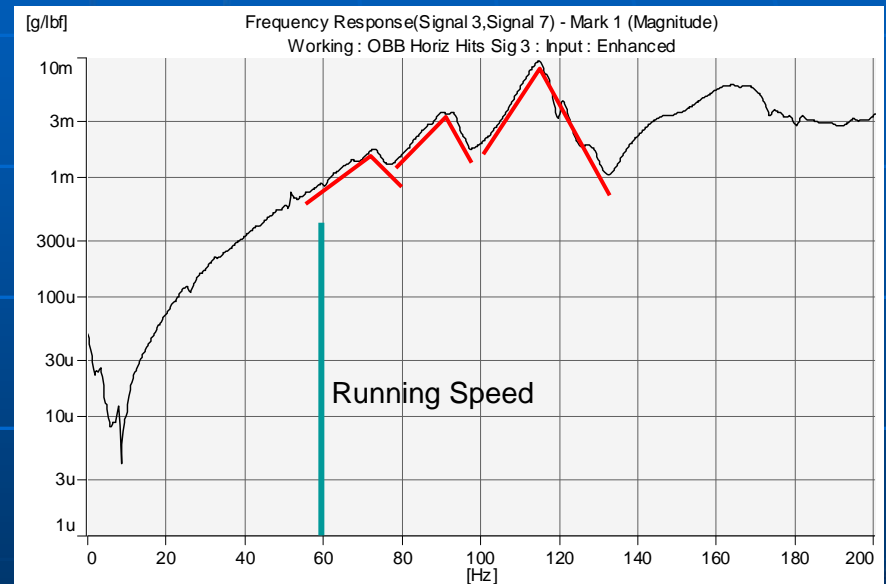
Natural frequency at 73 Hz (23% above 1x rpm)

Vibration EMA Test

Comparison of FRF from EMA Test (not Operating) in the Horizontal Direction at the Pump OBB Housing



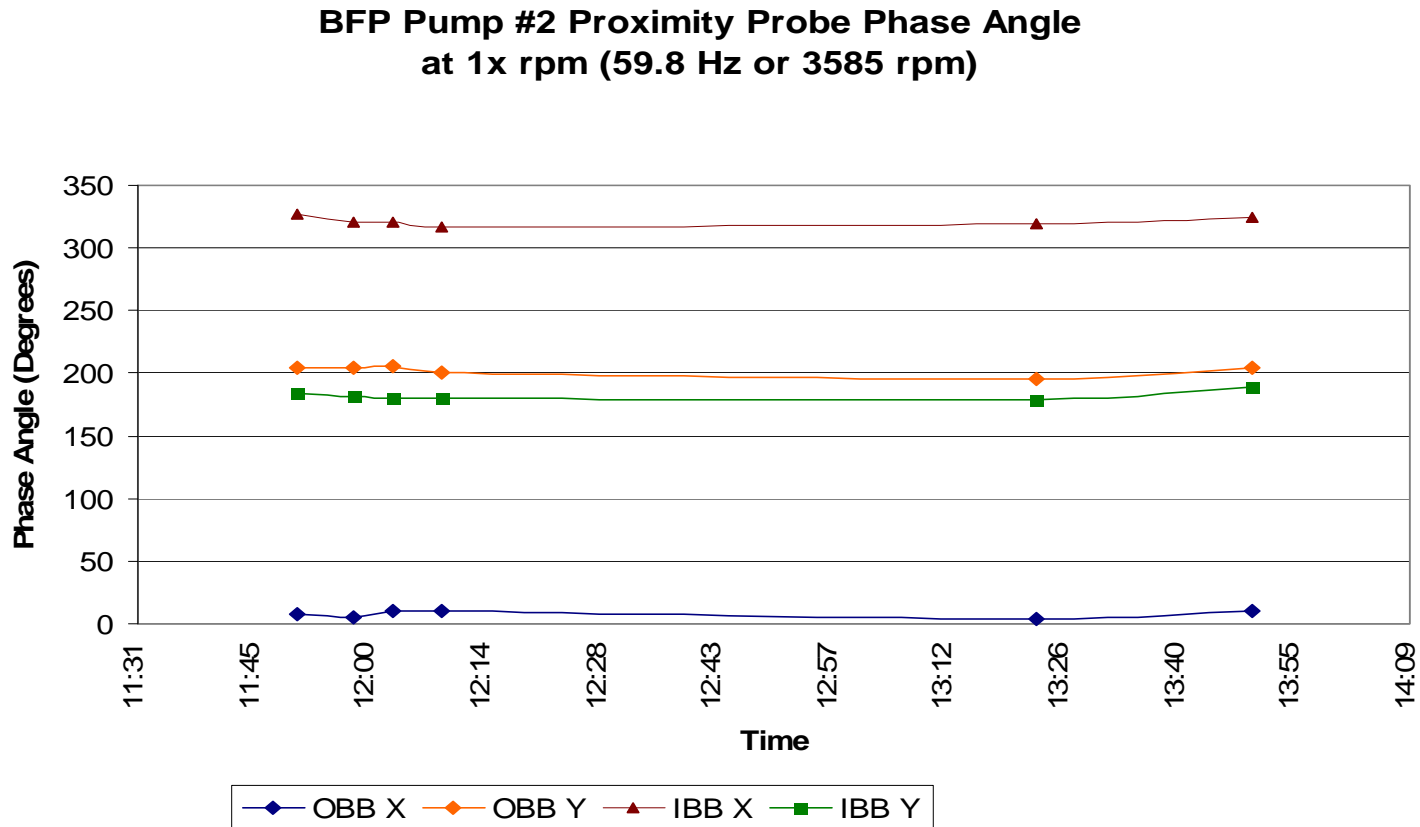
Before



After

Vibration Monitoring

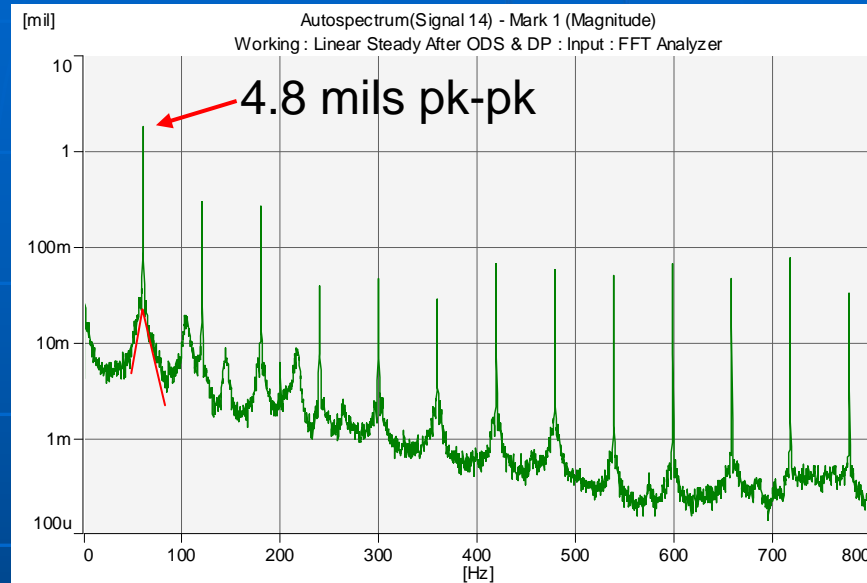
Pump #2 Proximity Probe Phase Angle Trend Plot After Implementing Modifications



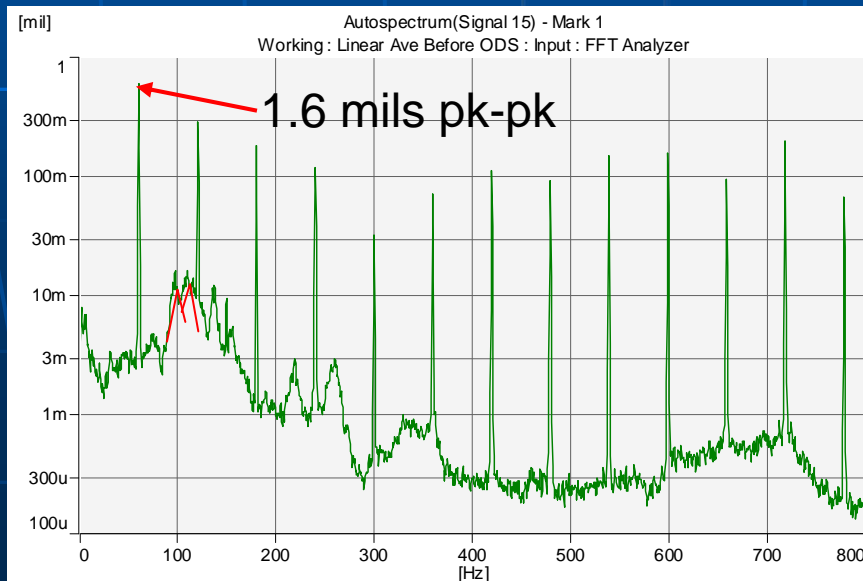
Vibration Monitoring

Pump #2 Shaft Spectra Before and After Implementing Modifications

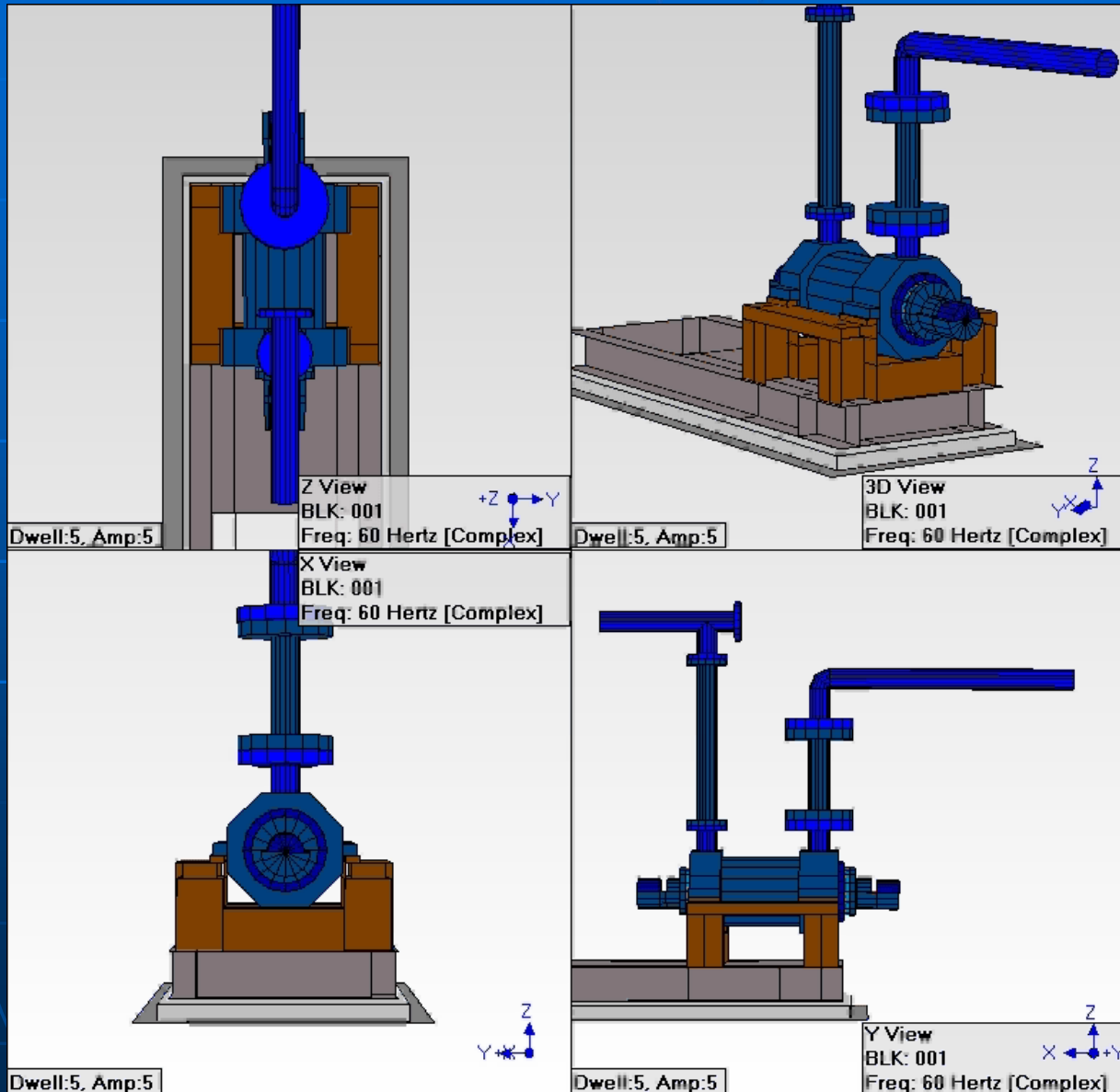
Before



After



Final Operating Deflection Shape



Conclusions

- The root cause of the vibration on Pump #2 was due to excessive flexibility at the baseplate caused by softness or delamination of the internal grout. This phenomenon originated due to the looseness of the anchor J-bolts.
- After all modifications performed on the baseplate, the maximum vibration amplitude at the OBB housing in the horizontal direction was reduced from 0.35 in/s peak to a greatly improved value of 0.09 in/s pk @ 1x rpm.
- The ODS is a powerful troubleshooting tool to facilitate and visually understand most common vibration problems in any pumping system or turbomachine.

Thank you

Any Questions...?