45TH TURBOMACHINERY & 32ND PUMP SYMPOSIA
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GEORGE R. BROWN CONVENTION CENTER

Solving a Sever Vibration Problem in the Downstream Piping of a Gear Pump

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Author's Biography

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Abstract

A solution was developed for an extreme discharge piping vibration problem on an 80 hp gear pump piping system. Maximum field-measured vibration levels were over 4 ips 0-pk (200 mm/sec pk-pk). Most gear pumps are not equipped with the typical pulsation dampeners that are found on plunger pumps because the relatively high frequency pulsations that gear pumps generate typically do not result in piping vibration problems. Modeling predictions indicated that the vibrations were primarily driven by pulsations. After implementation of a new gas-liquid dampener, the system vibrations were significantly reduced.

Agenda

- Introduce System & Problem
- Steps taken to Solve Problem
- Summary & Lessons Learned

Pump Description Details

Pumps Details
1 pump (gear)
8 teeth
Service: Turbine Oil
750-945 rpm
62 gpm at 756 rpm
78 hp at 756 rpm

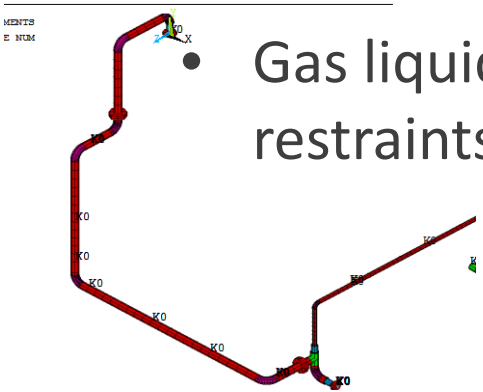
Pump Operating Conditions
Suction Pressure: 11 psia (0.8 bara)
Discharge Pressure: 160 psia (11.2 bara)
Temperature: 120-140°F (49-60°C)

Problems

- High downstream piping vibration:
  - Excessively high amplitudes: >100 mm/sec RMS (>4 inches/sec RMS)
  - measured near 102.5 Hz
  - Client reported that vibration amplitudes increase as the speed increases beyond ~750 rpm
- Al-Bayroni needs to run the equipment at higher speeds; however, vibration levels are stopping them from proceeding

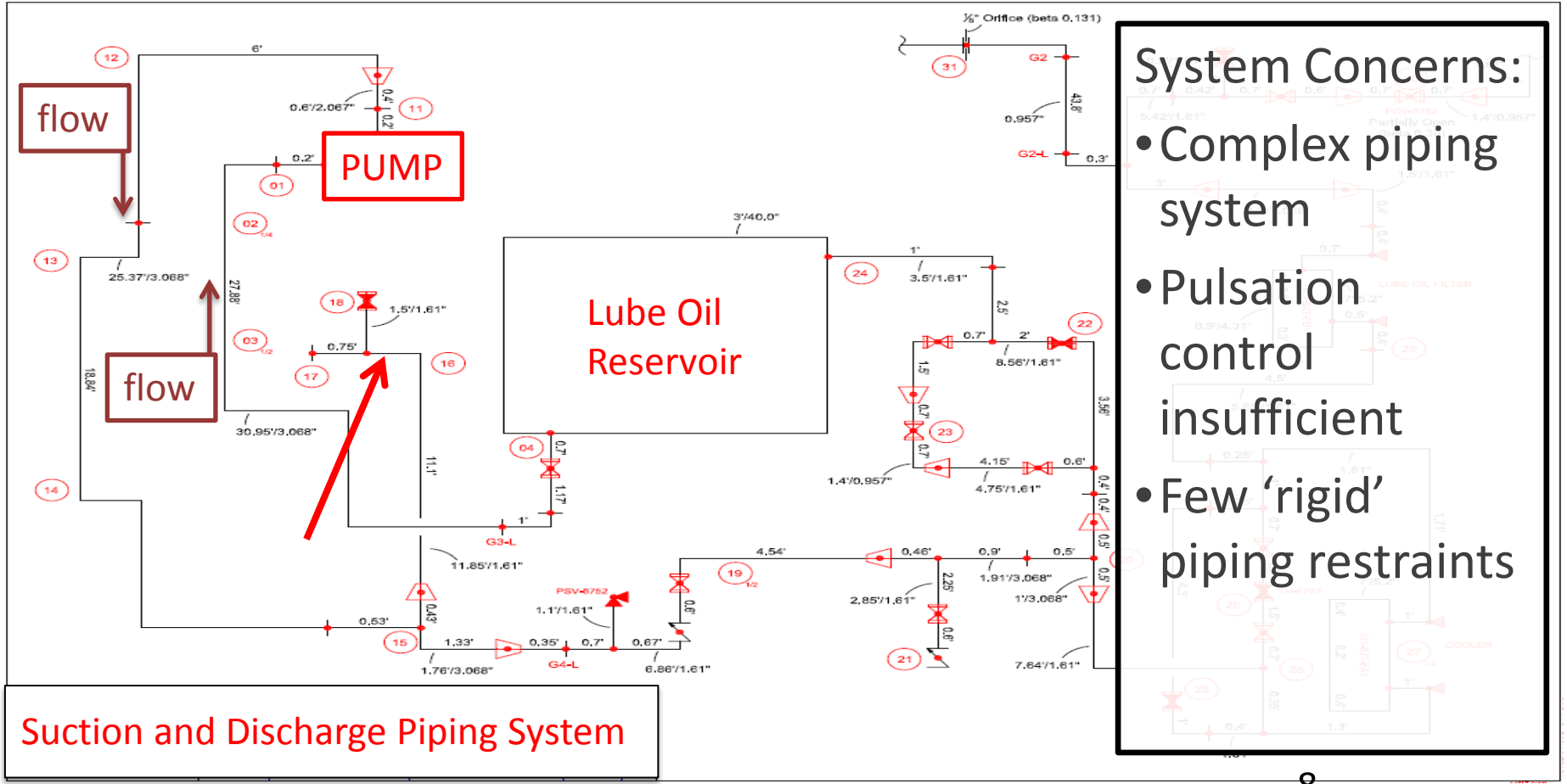
Steps Taken to Solve Problem

- Field investigation for problem characterization and diagnostics – vibration data measured by the client
- Pulsation and mechanical (modal) analysis conducted to develop potential solutions
- Gas liquid dampener and additional restraints recommended



Install the dampener near the pump

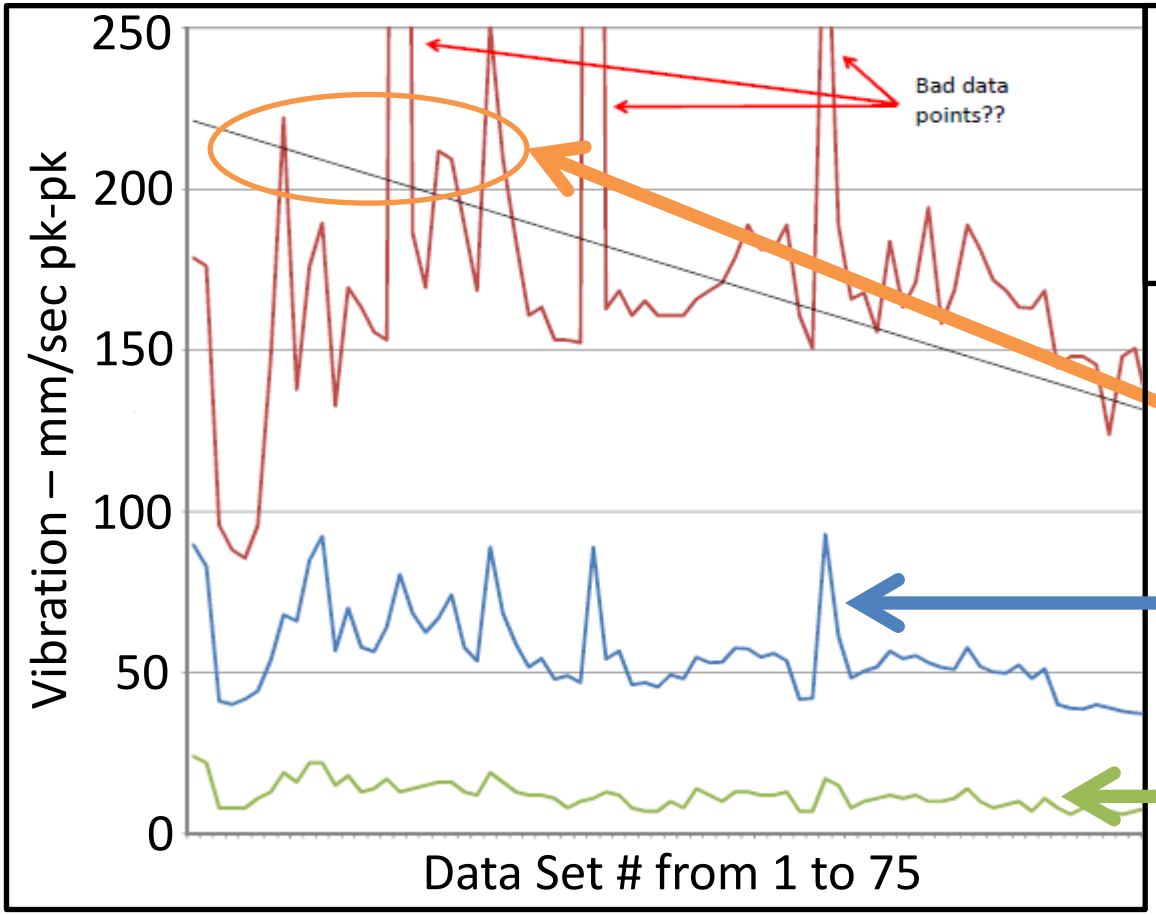
Piping Layout



System Concerns:

- Complex piping system
- Pulsation control insufficient
- Few ‘rigid’ piping restraints

Summary of Initial Field Measured Vibrations



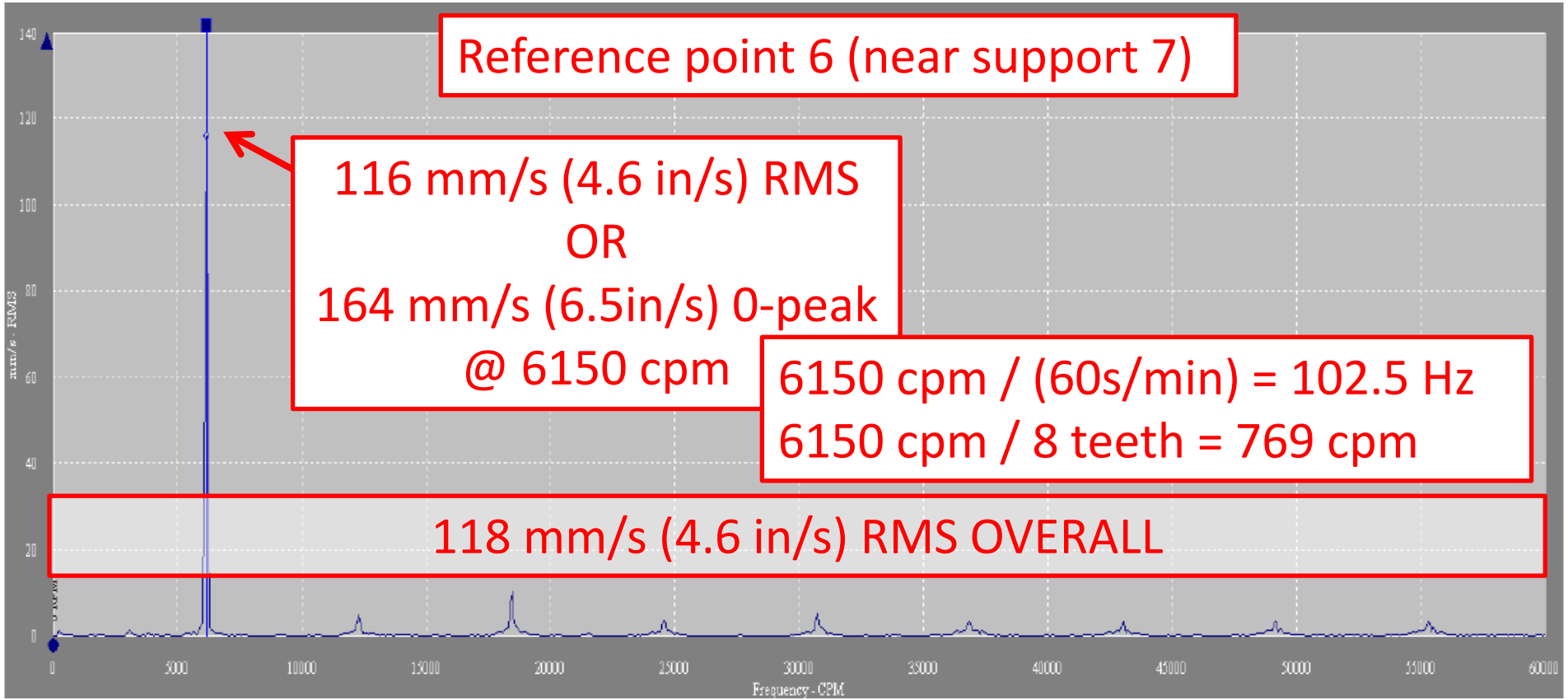
Key:
Peaks
Average
# of pts. > 50mm/s pk-pk

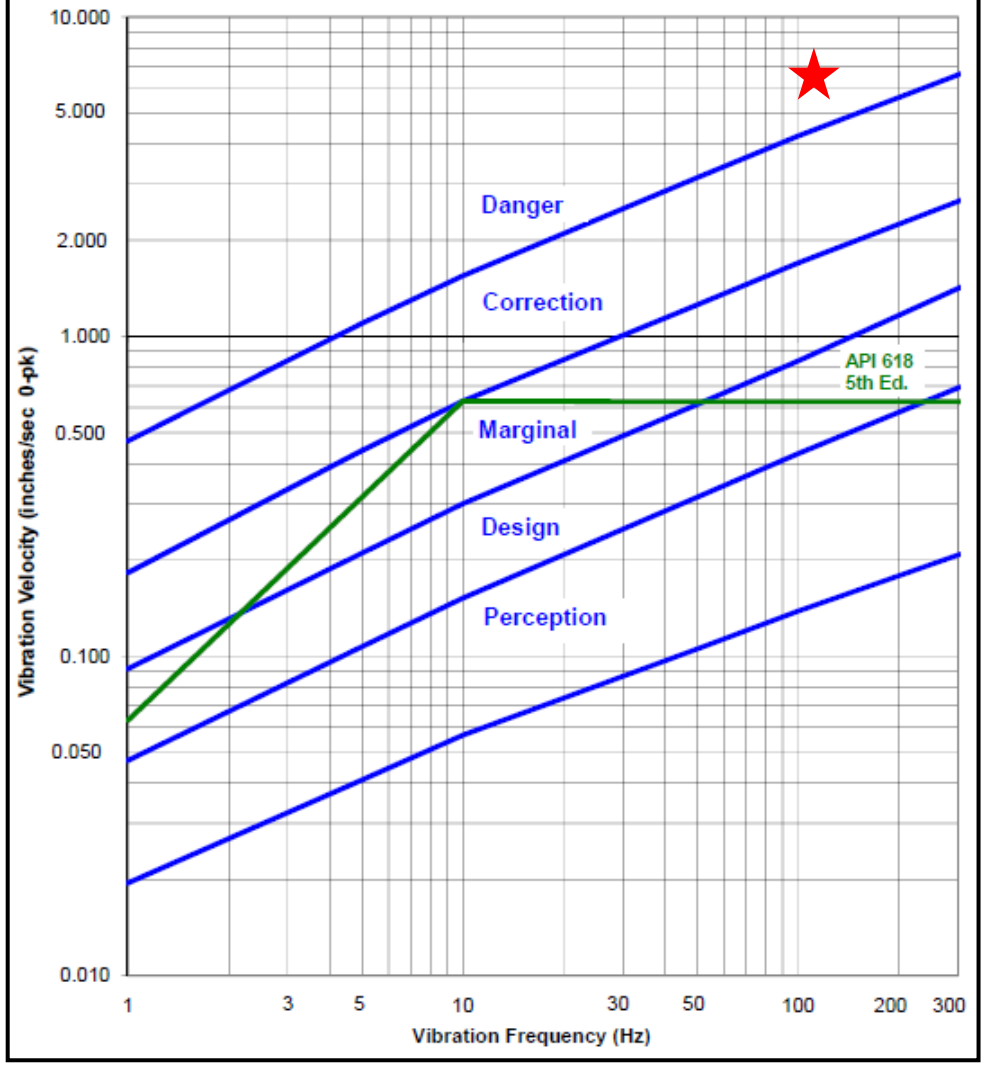
Peak values greater than 200 mm/s (8 in/s)

Average values near 75 mm/s (3 in/s)

# of points > screening criteria = 6 to 24

Field Vibration Data at Single Test Point

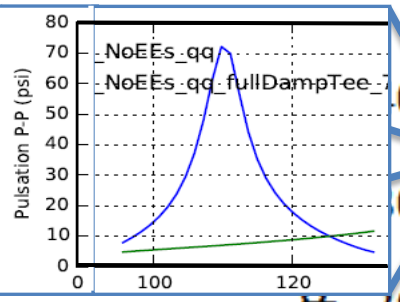




Field Vibration on SwRI Vibration Screening Piping Vibration Severity Chart

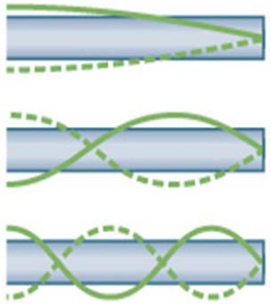
Field measured vibrations in **Danger** region

Pulsation Model Results



Existing System Pulsation: 70 psi pk-pk at 8x (110 Hz) at pump outlet

3rd quarter wave mode



Average Line Pressure of 160 psia (11.2 bara)

~Half Point

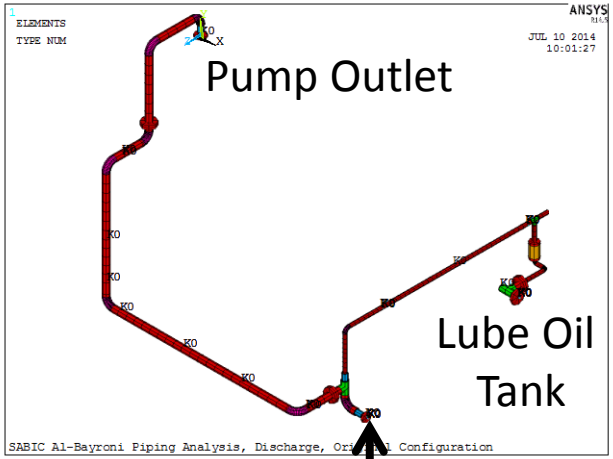
Quarter Point

Pulsation minimum is at lube oil reservoir

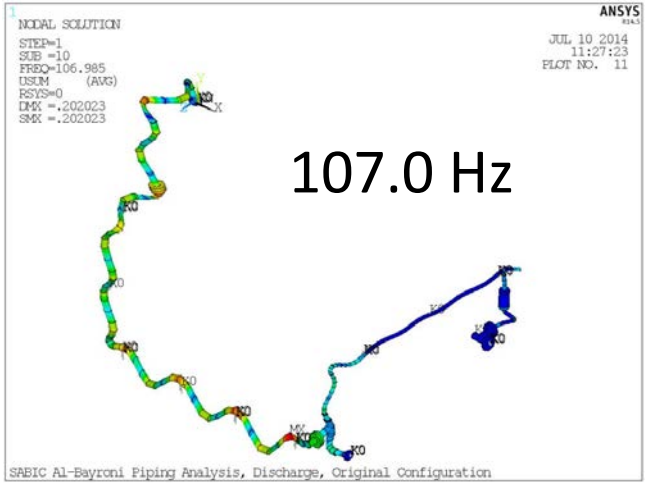
Pulsation Amplitude (

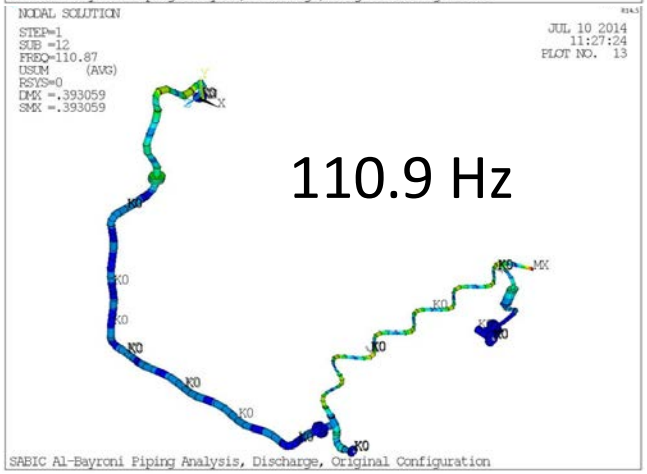
Length Downstream of Pump (feet)

Mechanical Analysis Recommended



Lube Oil
Supply Line

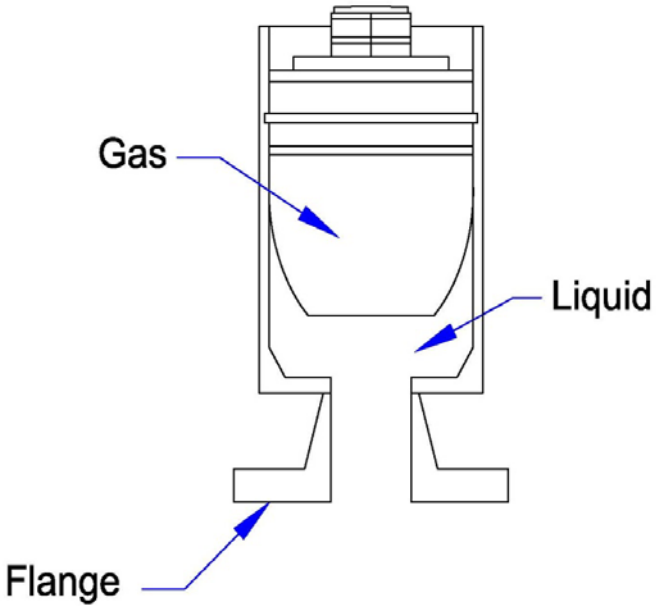




Recommended

- Dynamic support for dampener
- Pulsation & Mechanical mode shapes not coincident
- Dynamic support for rest of piping if vib. excessive after dampener installed

General Comments: Gas-Liquid Dampeners



- Pre charge gas filled bladder to fixed percentage of line pressure
- Pre-charged gas creates relatively large effective liquid volume to absorb pulsations
- Gas volume acts as spring compressing and expanding with line pressure changes

Gas Liquid Dampener

Note: Gas-liquid pulsation dampeners not previously attempted on this system, and not common on these types of systems

Recommended

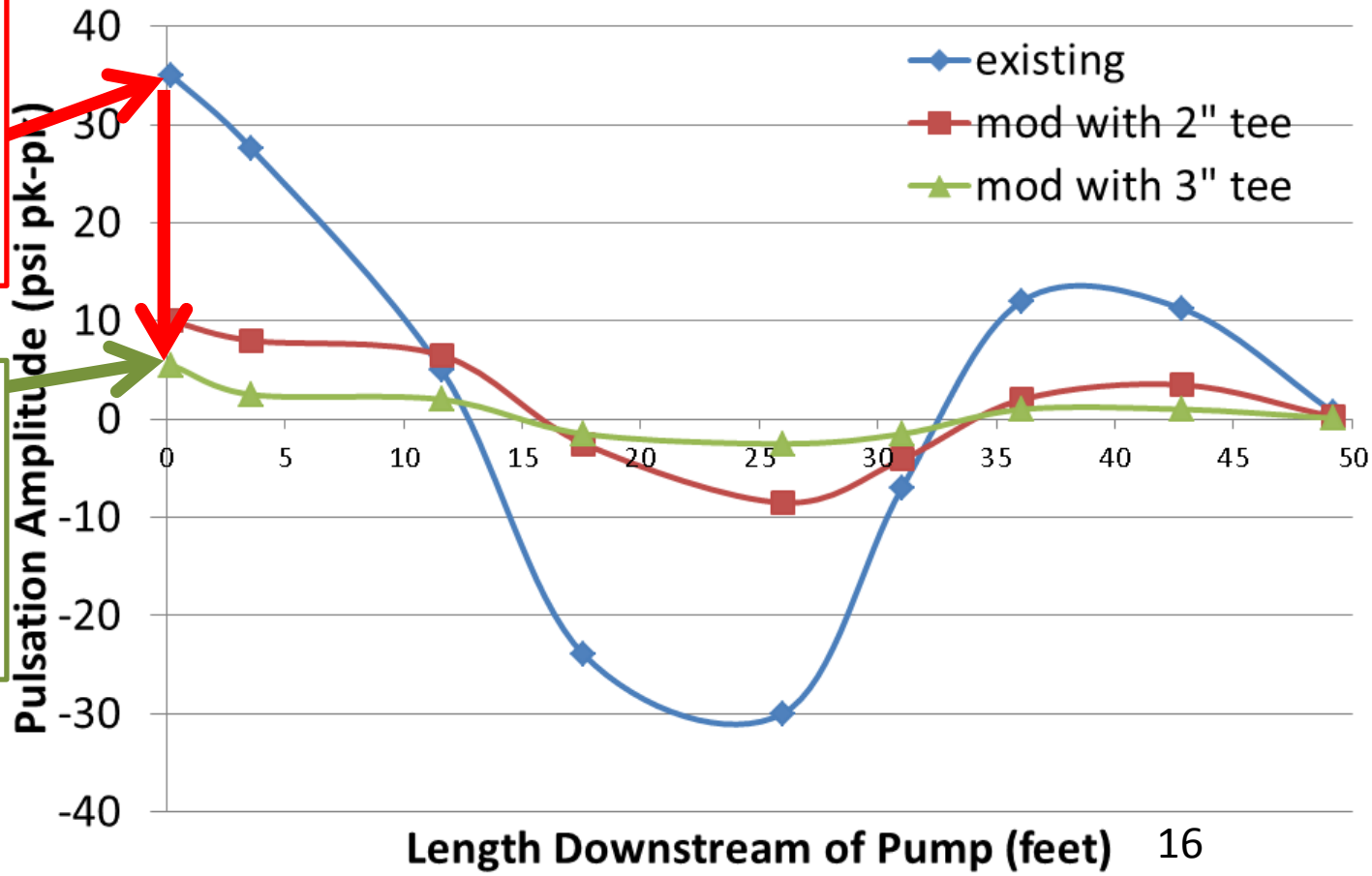
- 12 Liters of N_2 gas
- 3” (full) diameter connection
- as close as possible to pump outlet

Dampener sized to attenuate pulsations at teeth-frequency (8x running speed; primary excitation measured in field data)

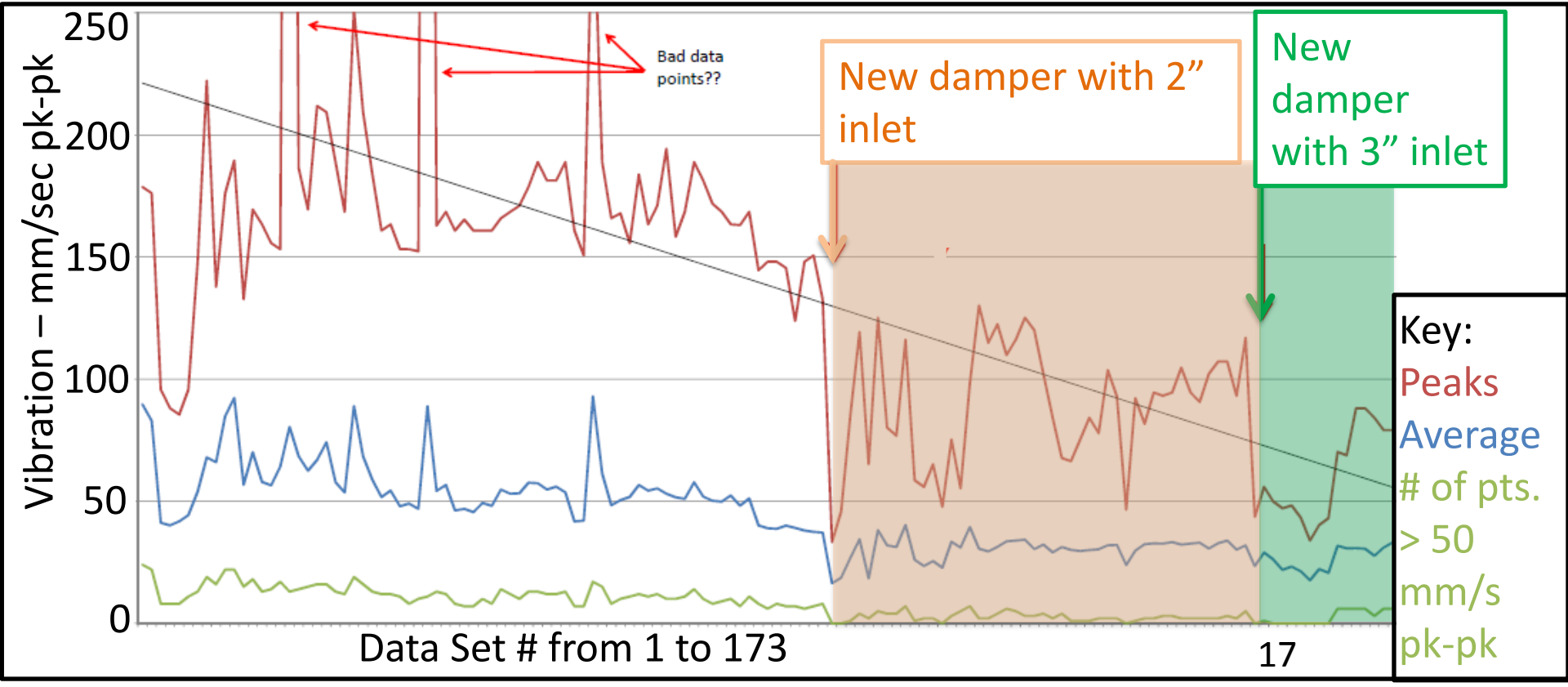
Pulsation Model Results – Before & After

Existing System 70 psi pk-pk at 8x

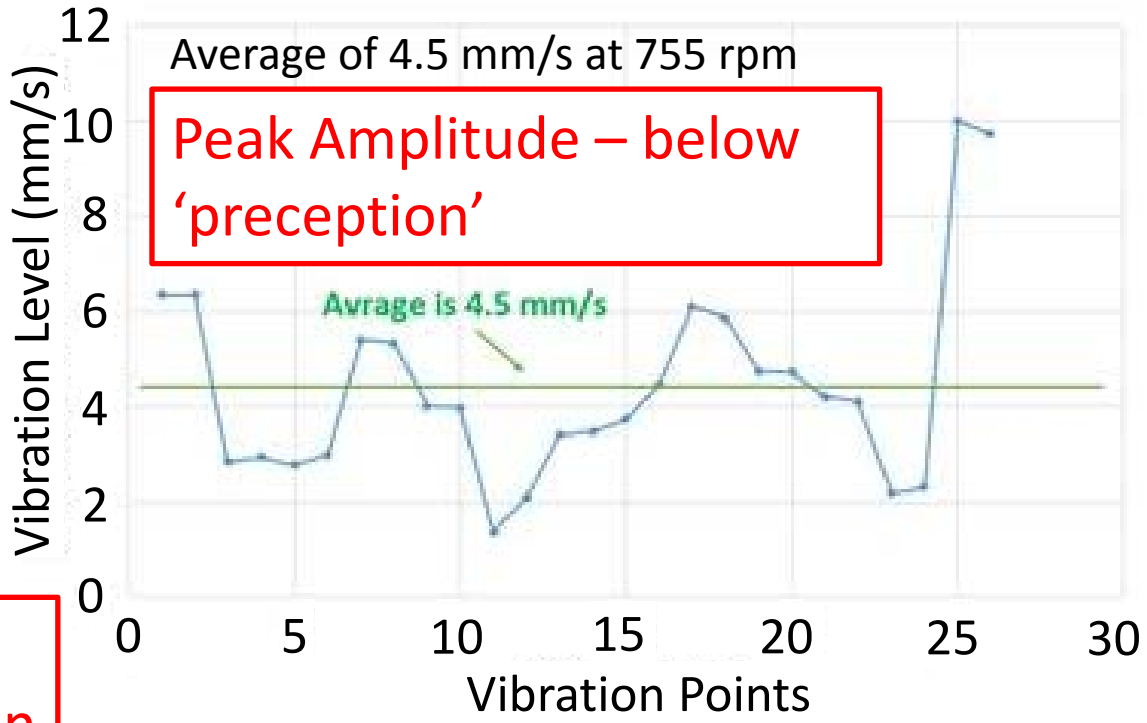
Modified System 11 psi pk-pk at 8x



Significant reductions in vibration amplitudes were observed after the gas-liquid dampener was installed.



Greater reductions in vib. amplitudes were observed after the gas-liquid dampener was installed closer.



Summary and Lessons Learned

- Pump System Problem
  - Excessive Vibration – 164 mm/s (6.5in/s) 0-peak
  - Vibration amplitudes increase as the speed increases beyond ~750 rpm
  - Client needed to run at higher speeds

- Steps taken to Solve Problem
  - Field investigation – vibration measurements
  - Pulsation analysis and mechanical modal of piping
  - Field modifications and confirmed improvement

- Lesson Learned: When properly applied, gas-liquid dampener can significantly reduce pulsation and vibration amplitudes, even for gear pump piping system