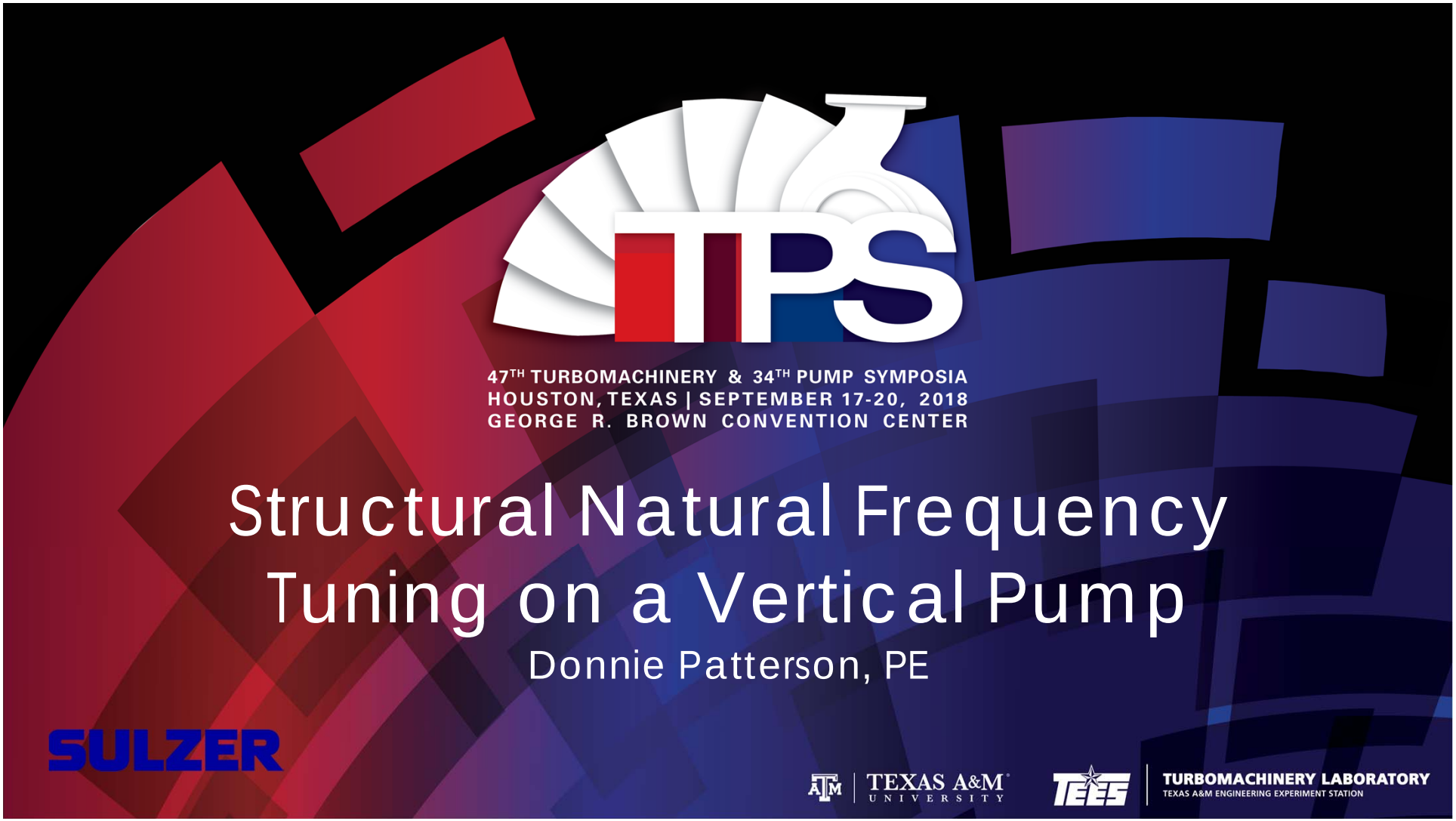

TPS
47TH TURBOMACHINERY & 34TH PUMP SYMPOSIA
HOUSTON, TEXAS | SEPTEMBER 17-20, 2018
GEORGE R. BROWN CONVENTION CENTER
Structural Natural Frequency Tuning on a Vertical Pump
Donnie Patterson, PE
SULZER
TEXAS A&M UNIVERSITY
TEES
TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

Author: Donnie Patterson

Donnie Patterson has been with Sulzer since 2007. He has held various positions within Sulzer including Design Engineer and Rotordynamic Engineer. He currently serves as a Field Engineer with Sulzer Pump Services Rocky Mountain Service Center in Denver, CO. He received his BSME from John Brown University and is a licensed PE in the State of Texas.

Abstract

Several pumps were experiencing high vibration in the field. They are VFD driven, VS1 style pumps. Vibration evaluation indicated an above grade natural frequency within the VFD operating range. Design changes to the discharge head and foundation were analyzed and predicted to raise the natural frequency above operating speed. The proposed changes were made to one unit and successfully reduced the vibration amplitudes to within acceptable levels.

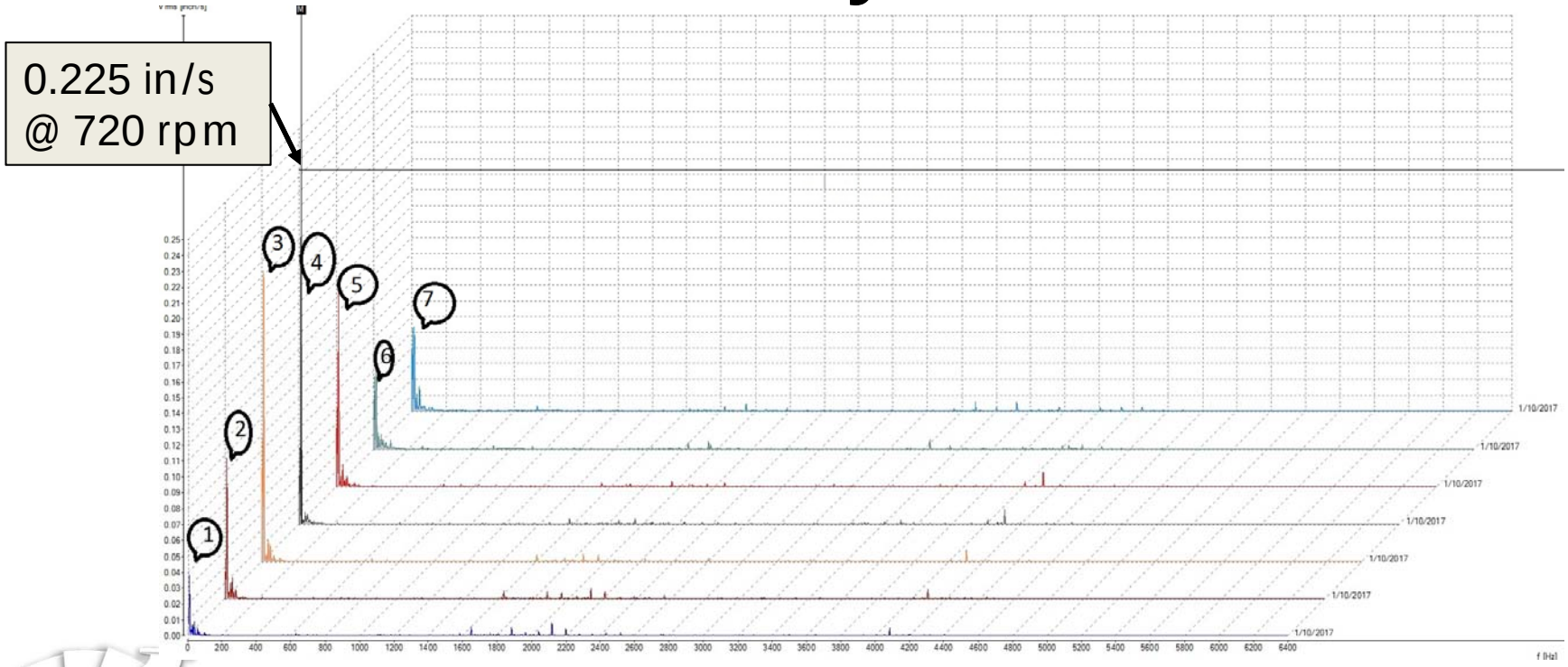
Background Information

- Existing VS1 style in condensate water service
- Rated for 148 feet at 9000 GPM running at 900 rpm
- 400 HP VSS motor
- VFD operated at 65%-100% speed (585-900 rpm)

Preliminary Review

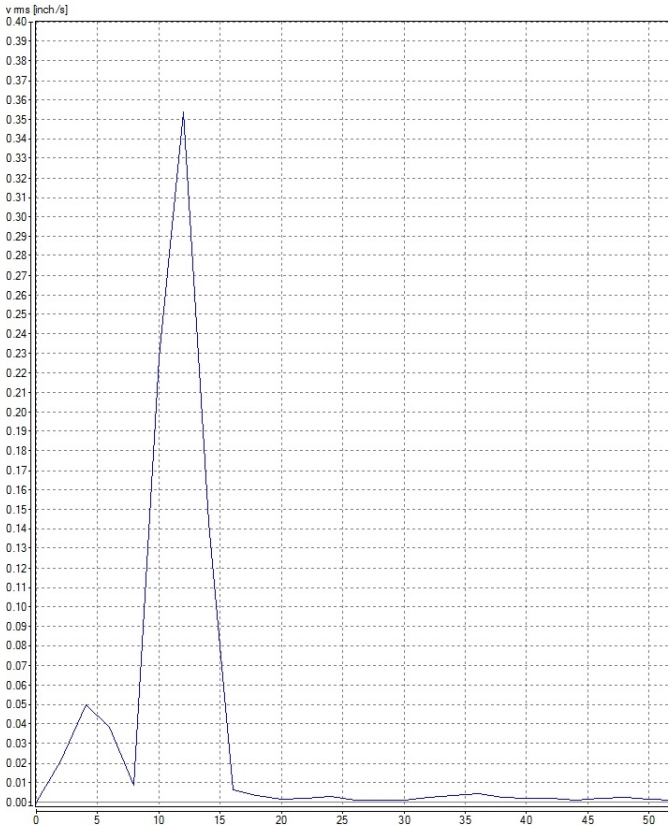
- Waterfall plot showed high vibration amplitude in the horizontal plane (0.22 in/s) at approximately 12 Hz when running at 80% speed.
- Bump testing indicated a natural frequency at 12 Hz, which correlated with operational vibration data.

Preliminary Review



WATERFALL PLOT FROM INITIAL VIBRATION EVALUATION

Preliminary Review



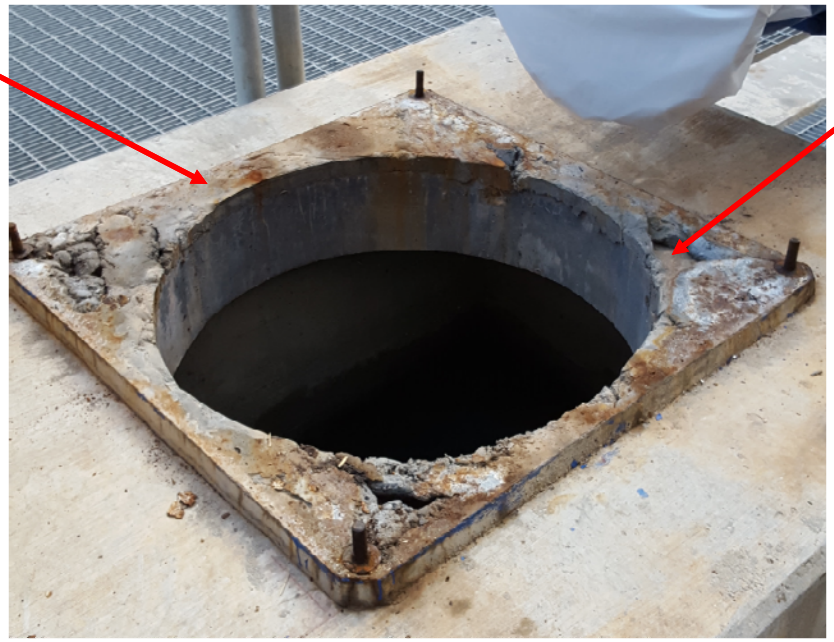
INITIAL BUMP TEST RESULTS:
PEAK AT 12 Hz

Preliminary Review

- Pump foundation showed poor grout conditions, with excessive voids and 100% delamination.
- Pump mounting plate was resting on nuts installed on the anchor bolts between the grout and mounting plate.

Preliminary Review

100% Grout delamination



Grout voids

Analytical Review

- Motor reed frequency of 28 Hz reported by vendor.
- As the motor RCF was significantly above run speed, it was decided to stiffen the discharge head to “tune” the natural frequency above run speed.
- A calculation based method was used to calculate natural frequencies of combined pump and motor.
- Different stiffening rib combinations were evaluated to determine the configuration that contributed the most stiffness.

Analytical Review

- Anchor bolt pattern modified from four to six bolts, with reduced bolt circle.
- Recommended re-grouting on the pump foundation.
- Removed nuts on anchor bolts under the mounting plate.

Modifications

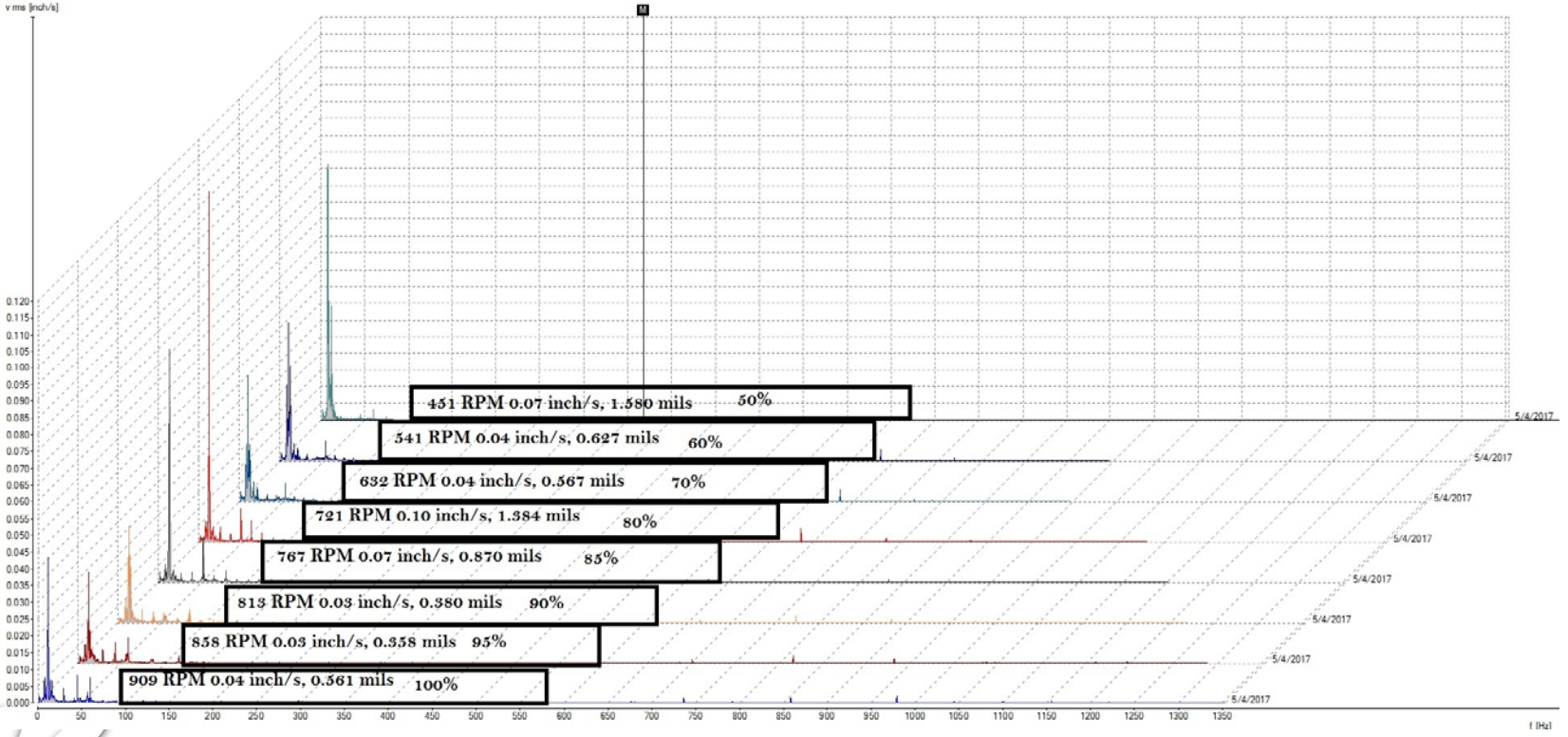
Before

After

Results

- Modified discharge head installed on one unit
- 1x vibration levels at 80% run speed (~720 rpm) decreased from 0.22 in/s RMS to 0.10 in/s RMS
- Customer happy with results and plans on making modifications to remaining units

Results



WATERFALL PLOT AFTER MODIFIED UNIT PUT BACK IN SERVICE

Key Takeaways

- Bump testing can be an effective tool for determining structural natural frequencies of equipment.
- If considering VFD retro fit on existing fixed speed equipment, recommend bump test or similar testing prior to retrofit to avoid “surprises” .
- Modifications to tune structural natural frequencies can be an effective method to shift natural frequencies away from operating speeds.

Key Takeaways

- Modification results depend on accurate field data! If on-site vibration equipment not adequate, consider third-party.
- Good practice to do vibration testing on modified equipment to verify results and provide new vibration baseline.
- Foundation conditions can impact structural frequencies (e.g. grout delamination).