TEXAS A&M UNIVERSITY

TURBOMACHINERY LABORATORY
TEXAS A&M ENGINEERING EXPERIMENT STATION

51ST TURBOMACHINERY & 38TH PUMP SYMPOSIA

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A Novel Approach to Installation of New Crude Bottoms Pumps

Presenter Biography

- **Bobby Souers** graduated from the University of Kentucky in 1980 with a Bachelor's of Science in Mechanical Engineering. He began his career with Ashland Oil in Catlettsburg, Ky and has been the owner and Principal Engineer for Equipment Reliability Services since 1998. He is a licensed Professional Engineer in the state of KY.

Abstract

- Metallurgy upgrades for high TAN crudes and existing NPSH problems required the installation of two (2) new Atmospheric Towers and two (2) new Vacuum Tower Bottoms Pumps.
- The new pumps are 450 HP and 1800 rpm versus the existing 3600 rpm and required a larger footprint. The new pumps were required to fit within the existing plot space. Pump, motor, and baseplate are 15,000 lb.
- Due to the metallurgy upgrades requiring replacement of all suction and discharge piping, the Turnaround schedule did not allow for extensive excavation and installation of new concrete foundations.
- An innovative approach was required to fit the new pumps into the existing plot plan and complete the installation within the Turnaround schedule.

New Pump Installation Challenges


Existing Pump Installation

- New pumps require 50% increase in baseplate footprint.
- Due to piping and unit access constraints, the pumps had to be installed in the same location between pipe support columns.
- Soil quality and bearing capacity required for new larger foundations was marginal.
- Underground sewer and drain piping could not be relocated.
- Estimated duration for traditional excavation and foundation installation was 25 days.

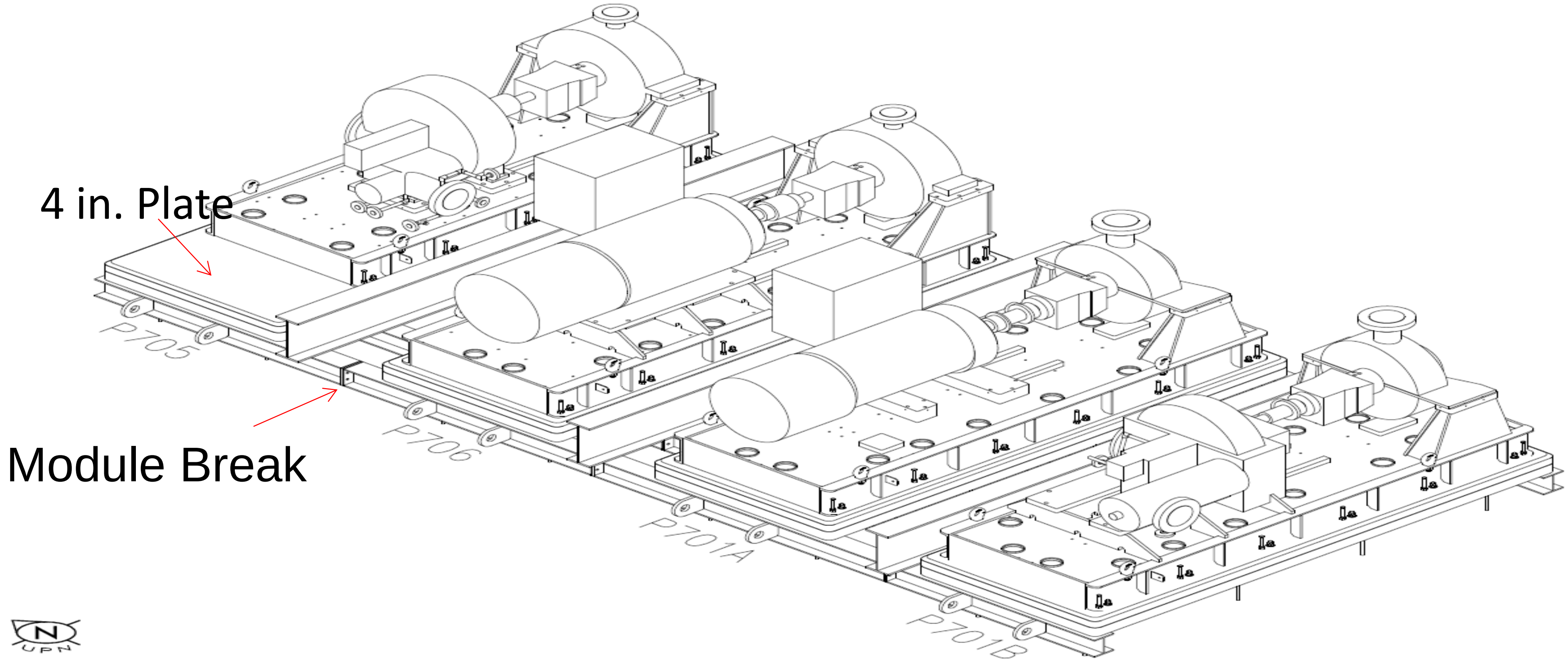
A Novel Approach to Installation of New Crude Bottoms Pumps

- A modular structural skid design that used the existing pump foundations for support was developed.
- The approach became “novel” in that few believed the pumps could be installed by any method other than traditional foundations.
- The structural skid design included four (4) modules supported by the existing foundations on steel/epoxy chocks.
- A dynamic analysis was performed on the structural skid to ensure structural resonances were avoided.
- One (1) pump baseplate was installed on each skid module and pre-grouted prior to the TA. The modules were installed individually, leveled, aligned, and bolted to form one composite skid.

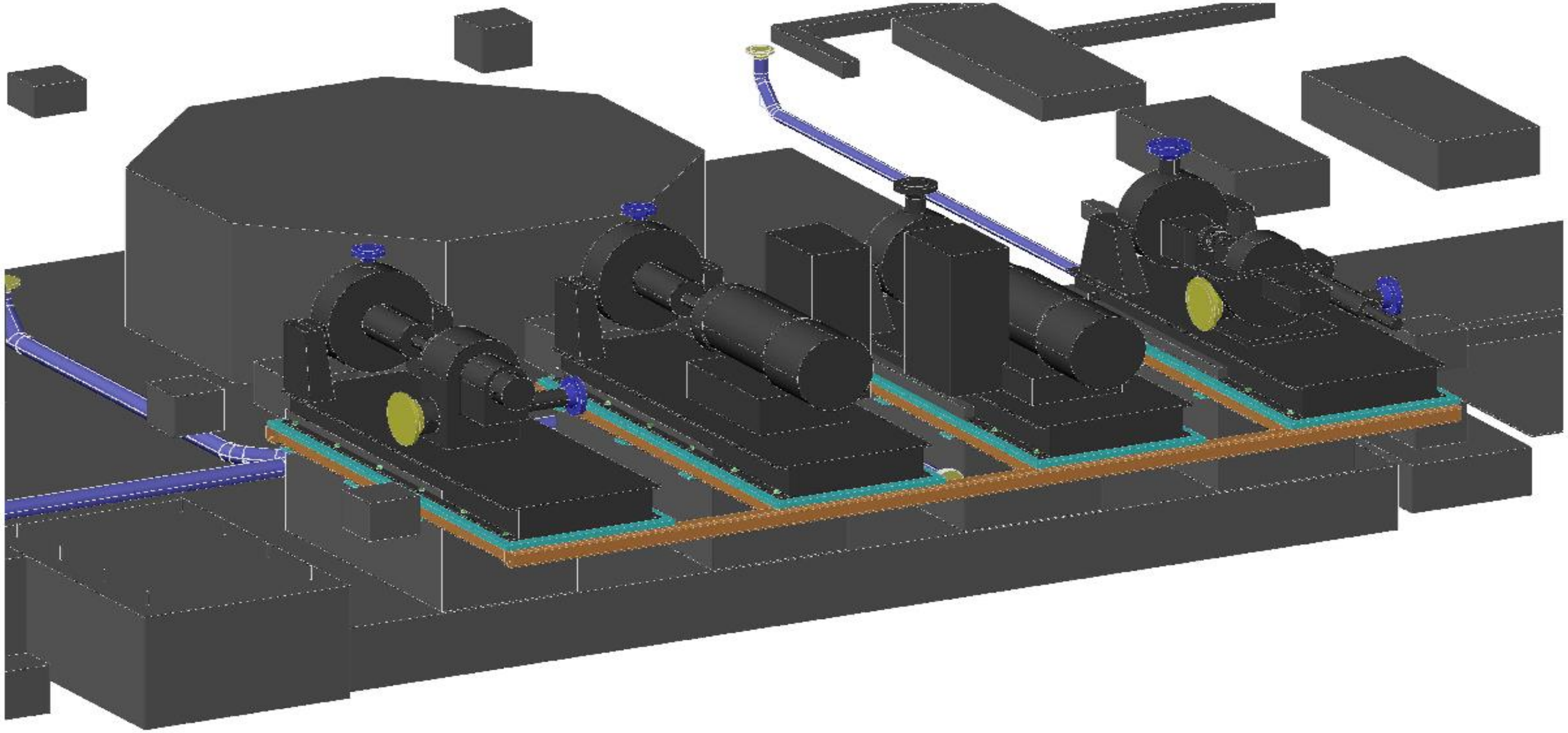
Structural Skid Design Concepts

- Four (4) structural frames bolted and dowelled together to form one composite skid. Structural Design required “zero” deflection during lifting.
- Each frame included a 4 in. thick steel plate for base plate mounting.
- Structural skid assembled pre-Turnaround, pumps and drivers installed and aligned, and removed for grout.
- Pump baseplates to be epoxy grouted pre-Turnaround.
- Pump structural skid disassembled into four (4) modules and staged for installation during turnaround.
- Individual skid modules to be installed on eight (8) steel chocks with core drilled anchor bolts, previously leveled and grouted onto the existing foundations.

Modular Structural Skid Design



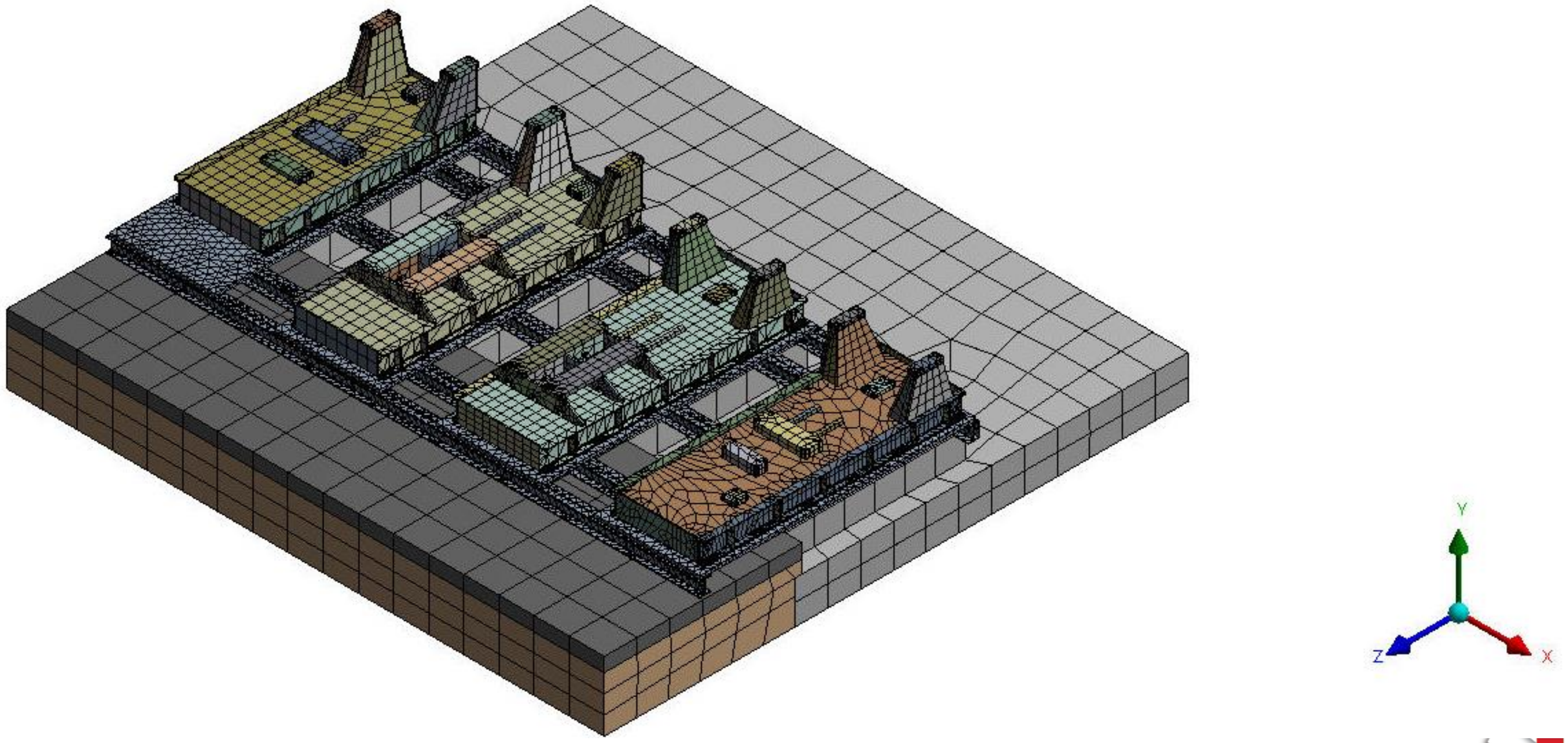
3D Model of Skid Installation



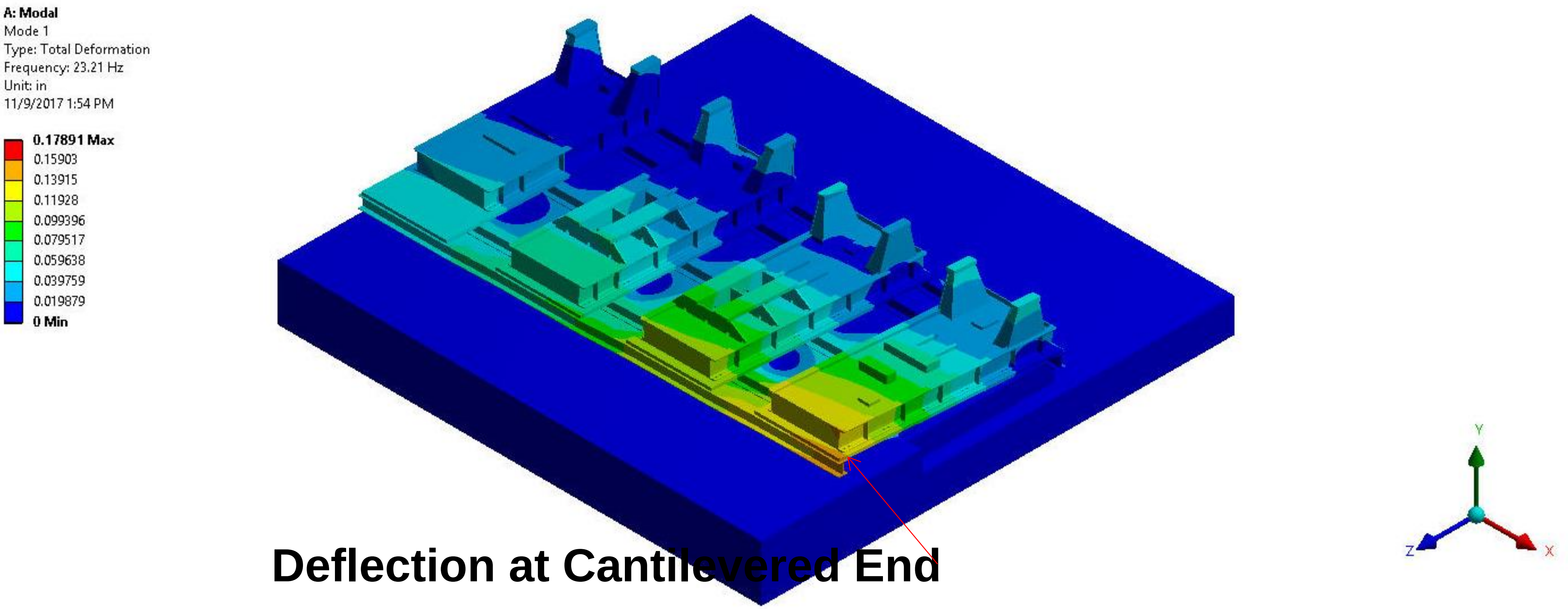
Skid Dynamic Analysis

- Concern for the possibility of structural resonance interference with pump operating speeds required a dynamic analysis be performed.
- The goal of the skid modal analysis was to ensure that all calculated modes of the skid assembly are at least 20% above running speeds of the pumps. Pump speeds are between 1665 rpm (27.75 Hz) and 1800 rpm (30 Hz).
- The initial skid design did not meet the separation margin requirement, as the first four modes were below 36 Hz.
- The skid design was modified to include eight (8) additional anchor bolts along the cantilevered end of the skid.
- The lowest calculated natural frequency with these modifications was 46 Hz, giving a separation margin of 53%.

Skid FEA Model

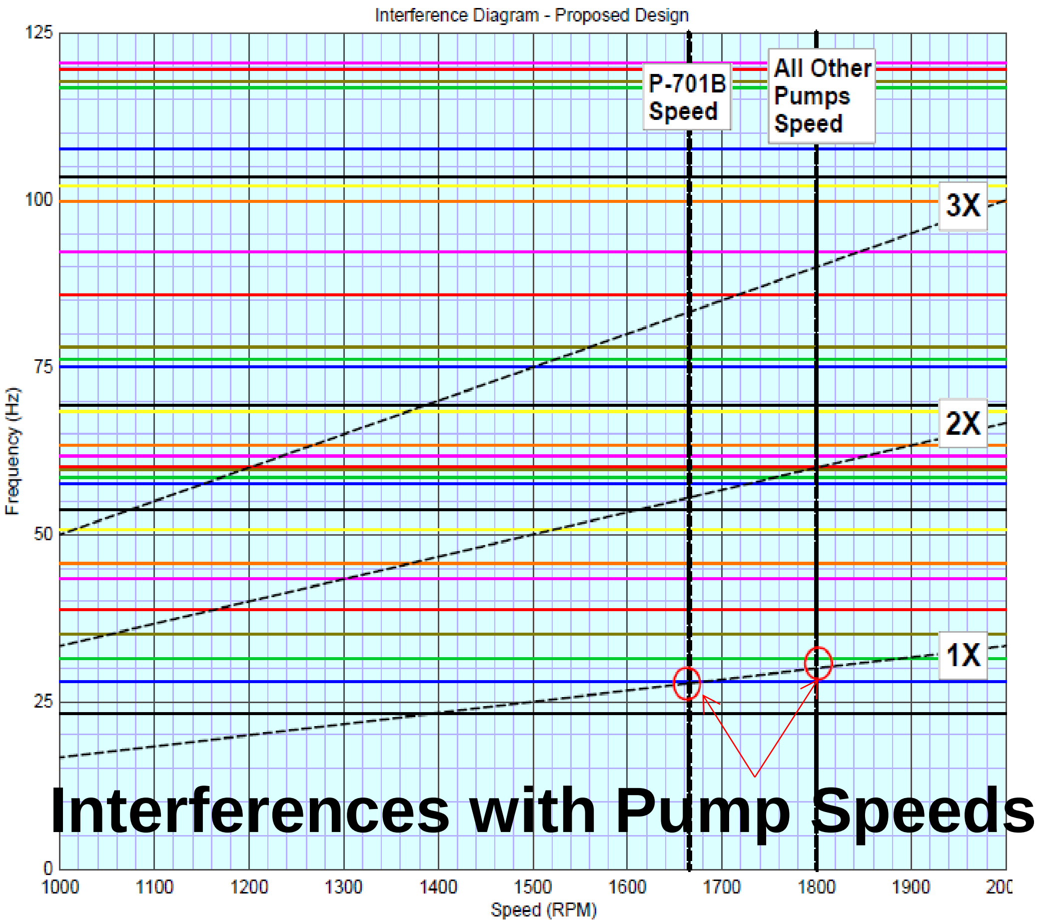


Skid Dynamic Analysis- 1st Resonant Mode at 23.21 Hz for Proposed Design



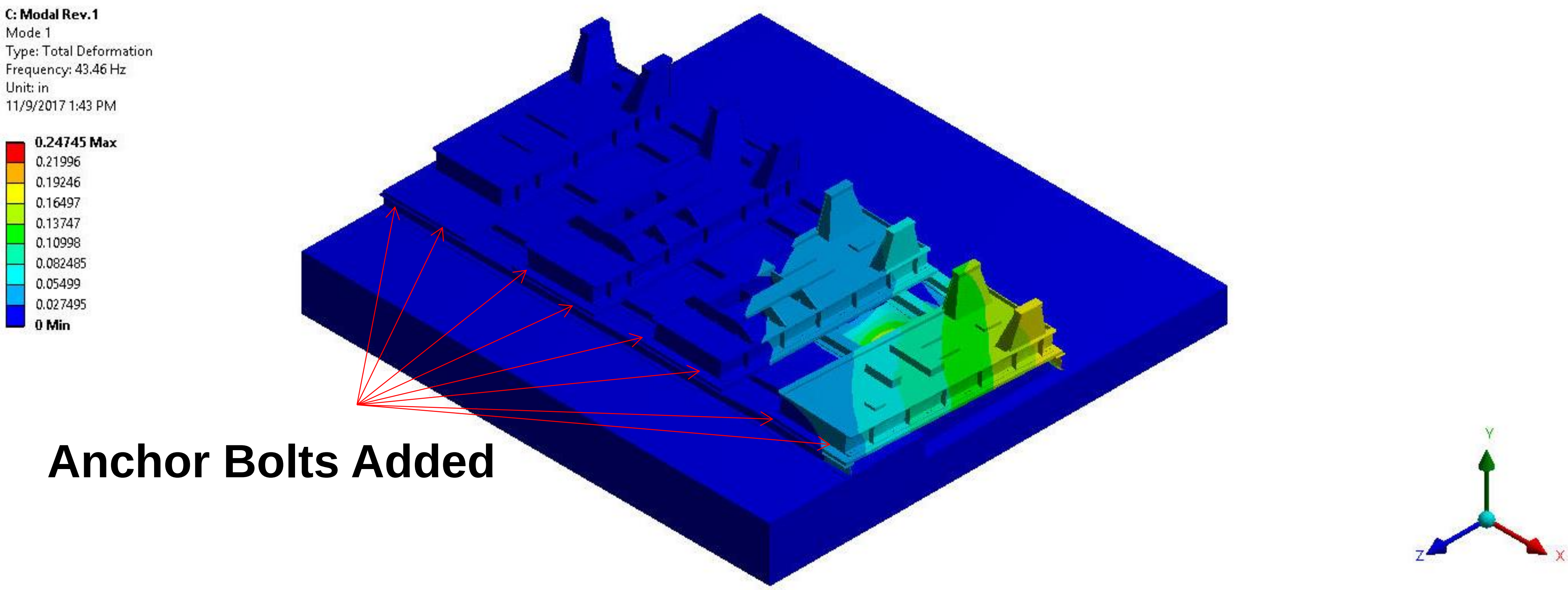
Deflection at Cantilevered End

Interference Diagram for the Proposed Design

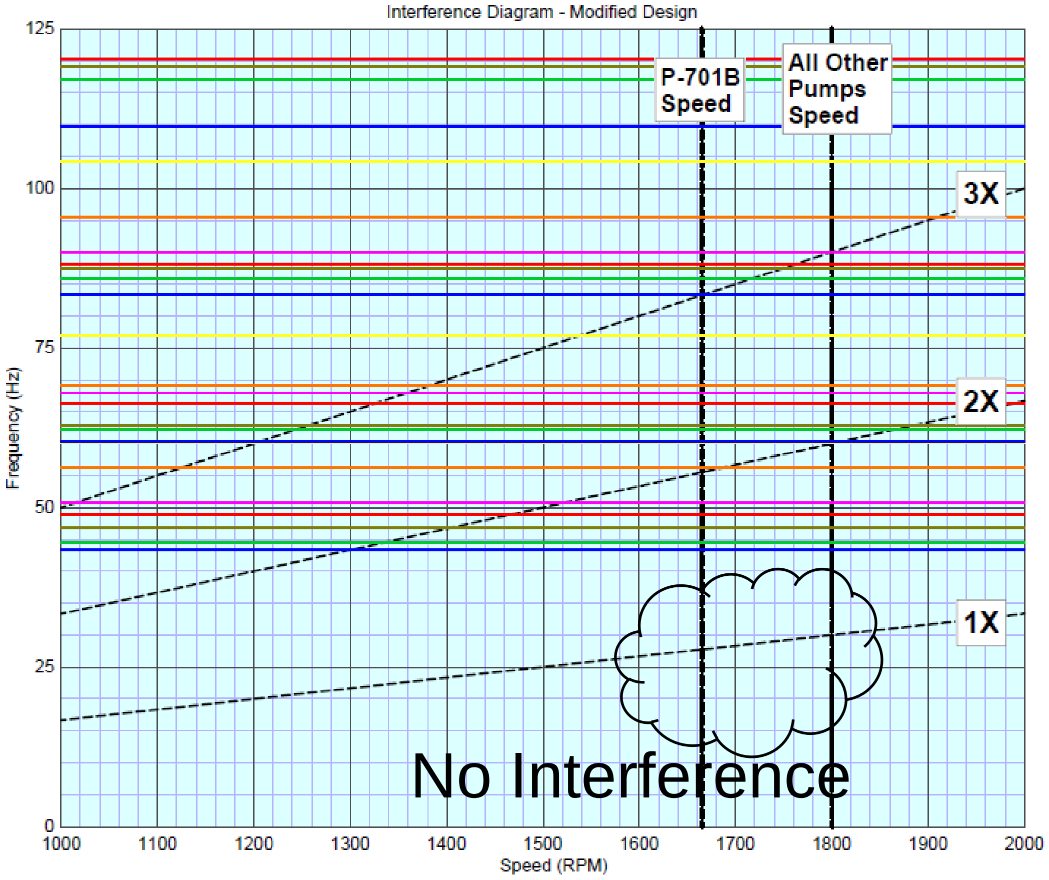


- 1st 4 Resonant modes are below the Separation Margin of 36 Hz
- Design does not meet the separation margin requirement of 20%
- Resonant interference at pump running speed of 1665 rpm and 1800 rpm

Skid Dynamic Analysis- 1st Resonant Mode at 43.46 Hz for Revised Design- Anchor Bolts added at End of Skid



Interference Diagram for the Modified Design with Additional Anchor Bolts



- 1st 4 Resonant modes are above the Separation Margin of 36 Hz
- Design does meet the separation margin requirement of 20%
- No Resonant interference at pump running speed of 1665 rpm and 1800 rpm

Pump Bases Installed and Skid Leveled

Base Plates Epoxy Grouted Pre-Turnaround

- Assembled skid enclosed in a heated 30 ft. x 60 ft. containment.
- Each pump baseplate was grouted per procedures the same as on a concrete foundation.
  - Leveled to 0.002 in./ft.
  - Expansion joints installed less than 42 in.
  - Forms of Melamine with chamfer strips and coated with wax

Grout Preparation and Pour

Grout Finish and Expansion Joint Fill

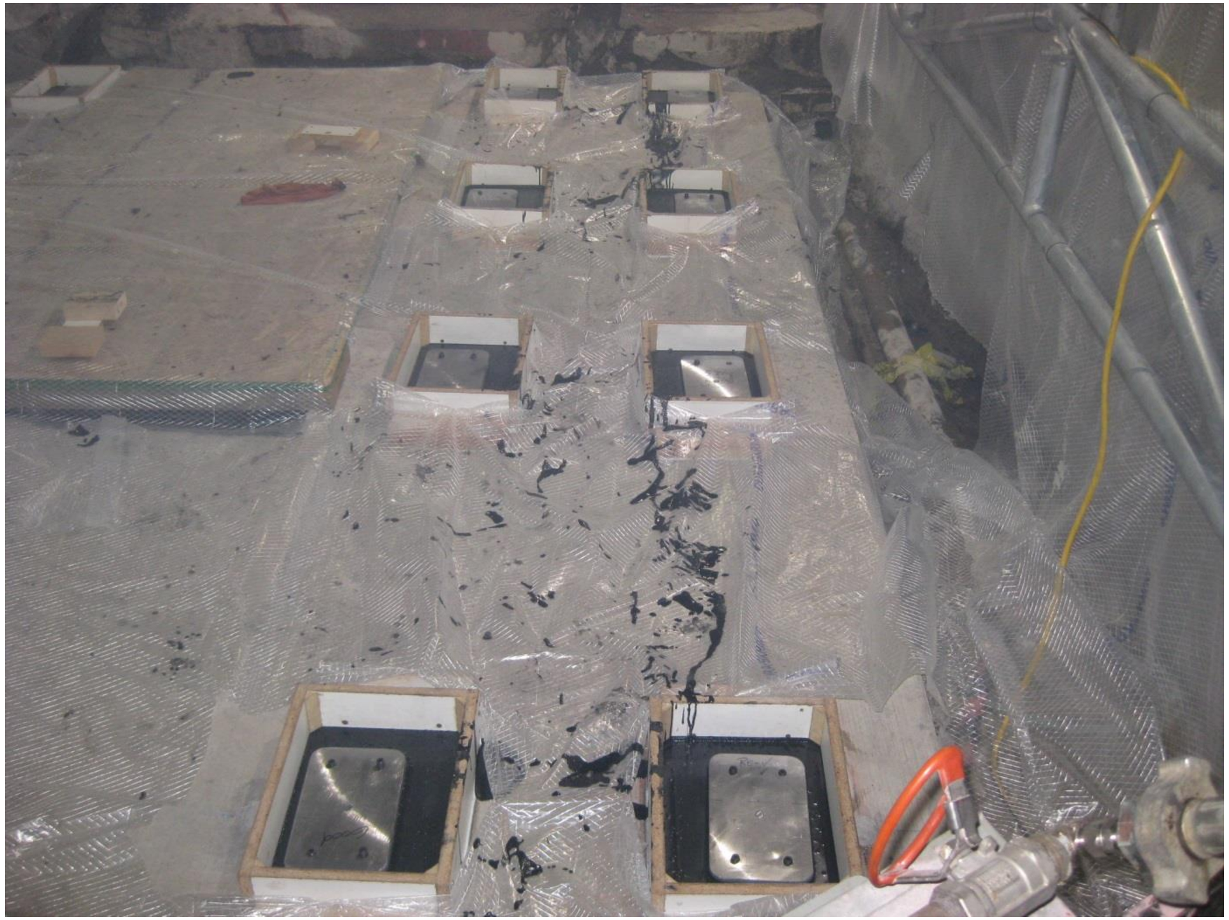
Removal of Existing Pump Foundations by Diamond Wire Cutting

Anchor Bolt Template

- The structural skid required 32 anchor bolts over a 15 ft. x 30 ft. area.
- Concern for maintaining dimensional tolerances of +/- 1/8 in.
- Prior to pump installation, the skid was assembled upside down and a wooden template made to locate the anchor bolts.
- After the existing foundations were removed the template was installed and the anchor bolt locations marked for core drilling.
- Anchor bolt locations were then verified by electronic/optical transit.

Setting and Leveling Chocks- Leveled to 0.0005 in/ft. and 0.002 in coplanar between chocks

Steel Chocks Epoxy Grouted



Cantilevered Boom Used to Install Skids Under the Pipe Rack- Spreader Bar lift to Minimize Distortion

Pump Skid Assembled and Leveled

- As each skid module was installed it was leveled with shims at the steel chocks.
- Modules were bolted together to form the composite skid.
- Each baseplate was verified for level within 0.005 in./ft.. Only one (1) baseplate was greater than 0.002 in./ft.
- Open areas of the skid and surrounding pavement were filled with lean concrete fill.

Pumps and Drivers Installed and Aligned

Conclusions and Lessons Learned

- The four (4) pumps were successfully installed in 7 days/14 shifts- ready for pipe installation.
- The modular skid design is a technically and economically viable option for pump installation when site constraints limit more traditional options
- Upfront technical review and Dynamic Analysis are required to ensure reliable operation.
- Detailed execution planning was required to meet the schedule. The plan had over 180 task items.
- Pumps have been in operation since 2018 with less than 0.15 in/s vibration and a max of 0.20 in/s at MCSF. Existing pumps operated at two to three times that amplitude.