53RD TURBOMACHINERY & 40TH PUMP SYMPOSIA

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Existing Compressor Skid Vibration: Anchoring & Grouting Upgrade

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Author Bios

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Ken Gerdes is the manager of Techmar, a company specializing in equipment foundations. He provides classroom and field training while managing field technical representatives. He is based out of southeast Iowa and services projects nationwide. Ken has helped design and install equipment grout since 2008 in many industries including food and chemical processing.

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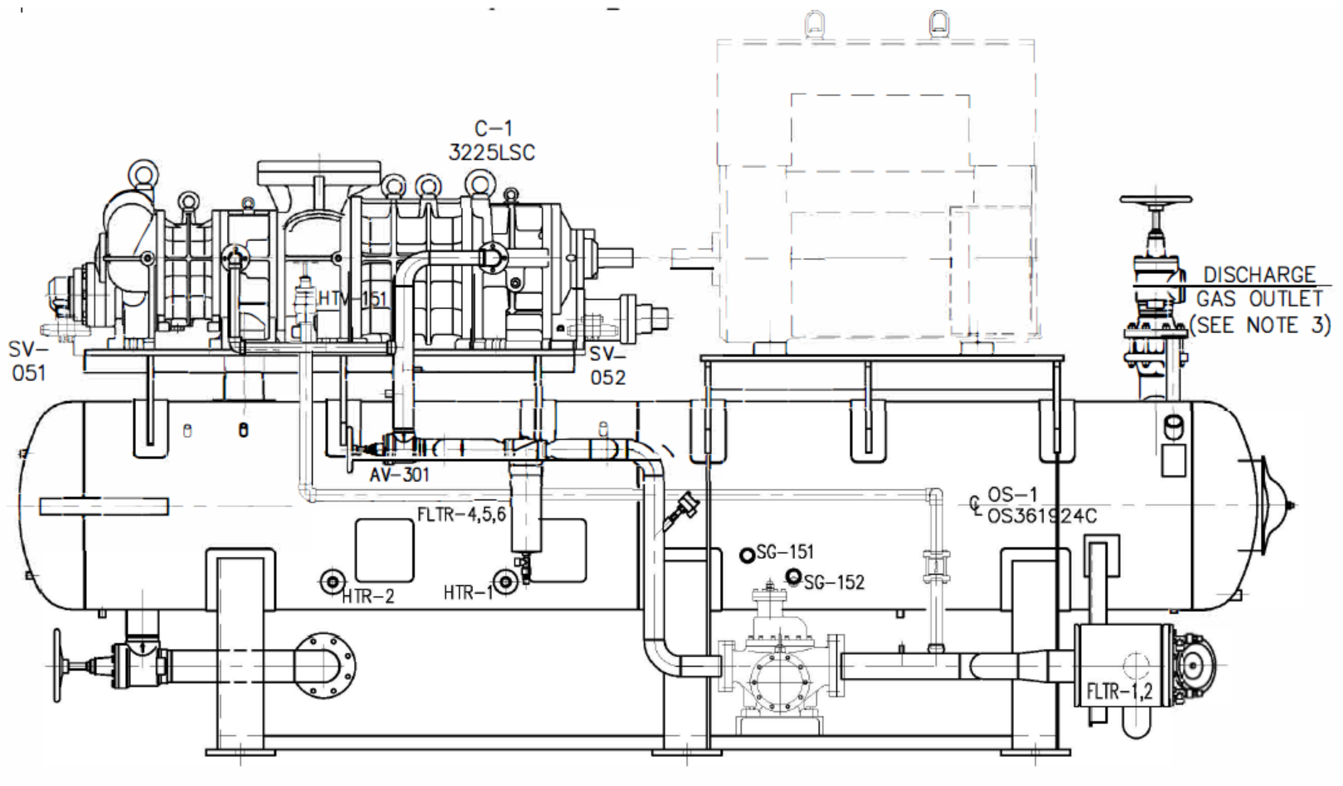
Abstract

This case study will provide attendees with detailed information on an intervention to a two-stage rotary screw compressor that was experiencing high vibrations. The intervention was designed and executed through a collaboration between end users, contractors, and product representatives.

The final remediation included adding anchor bolts and epoxy grout under the critical load supporting members of the frame while preserving placement and connections of the compressor skid and surrounding process equipment and resulted in an overall decrease in operating vibrations.

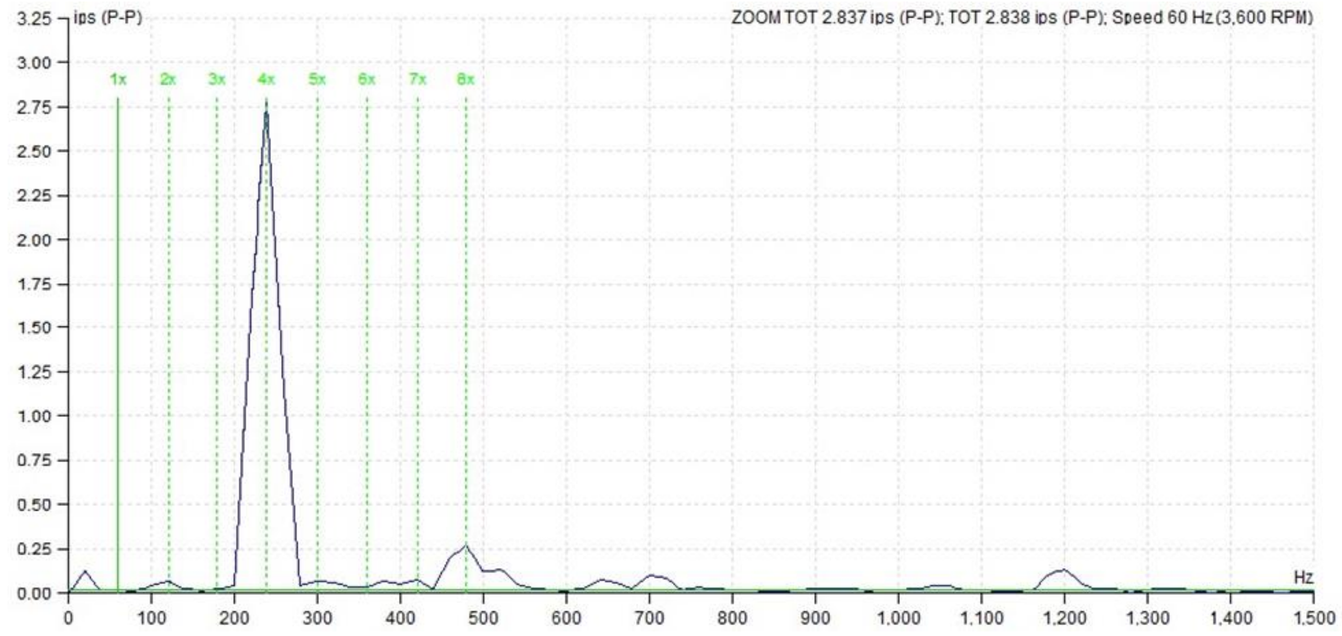
Problem Investigation / Overview

- 1500HP electric motor-driven
- Two-stage compressor
- Oil-flooded rotary screw design
- CO_2 Service
- Commissioned in 2008
- Arrived and initially installed as a full package including compressor, motor, and coalescer vessel
- Initial identification of excessive vibrations at least as early as 2022
- Vibrations trending higher than the rest of the fleet of similarly designed packages



Problem Investigation / Identified Problems

- High vibrations during operation measured on frame, compressor, coalescer vessel, & motor
  - Bordering the realm of compressor degradation
  - Data collected with continuous casing vibration monitor in conjunction with structure analyzed with a handheld vibration meter.
  - High readings trigger engineering alert.



Problem Investigation / Identified Problems

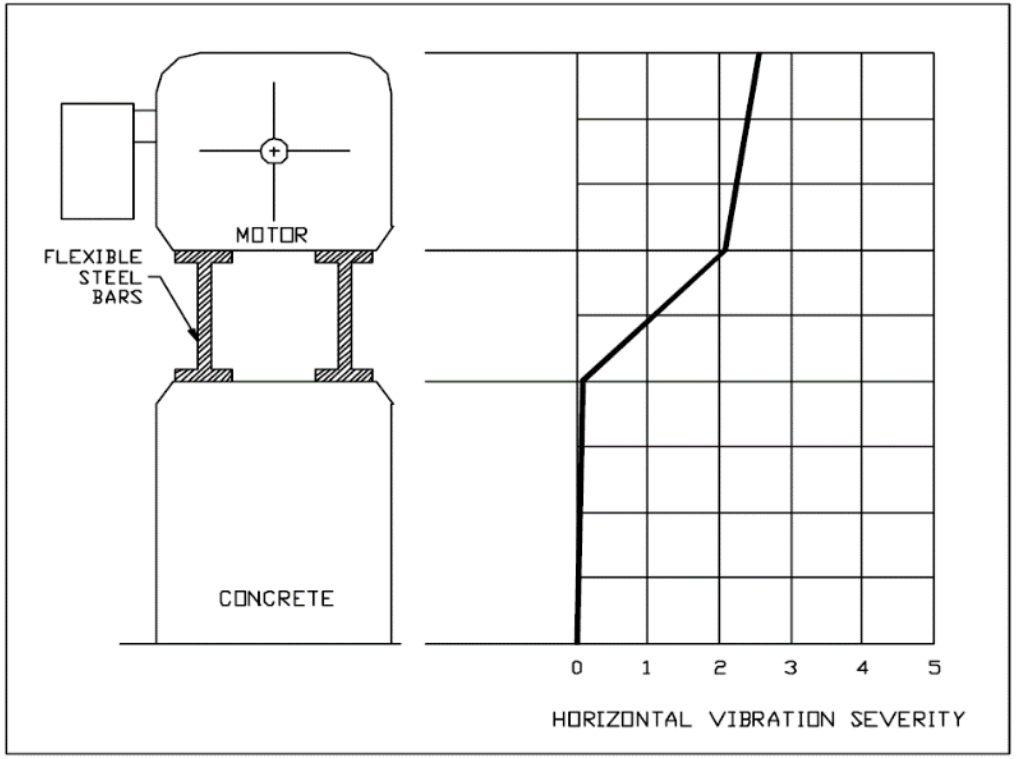
- Handheld spectral analysis
  - Frequency spectrums confirmed vibration source to be gas pulse frequency of the compressor.
- No anchor bolts or other connection devices between foundation and skid
- Minimal cementitious grout under perimeter beams
- Compressor and driver loads on interior beams

Problem Investigation / Solution Investigation

- First replaced the Compressor with spare
  - Previous compressor last rebuild was 2015
  - Vibration readings increased slightly from before
  - Gave evidence vibrations unrelated to mechanical damage within compressor, such as to rotor
- Adjusted process conditions to change pressure ratios to optimum design
  - Vibration readings unchanged

Problem Investigation / Solution Investigation

- Followed up with site visit
- Used handheld vibration monitor looked at frame and skid vibrations
  - Expected to see vibrations decrease as distance increased from vibration source
  - Measured higher vibrations as moving away from the compressor
  - Evidence of amplification and improper skid stiffness
  - Referenced OEM Motor Vibration guidelines



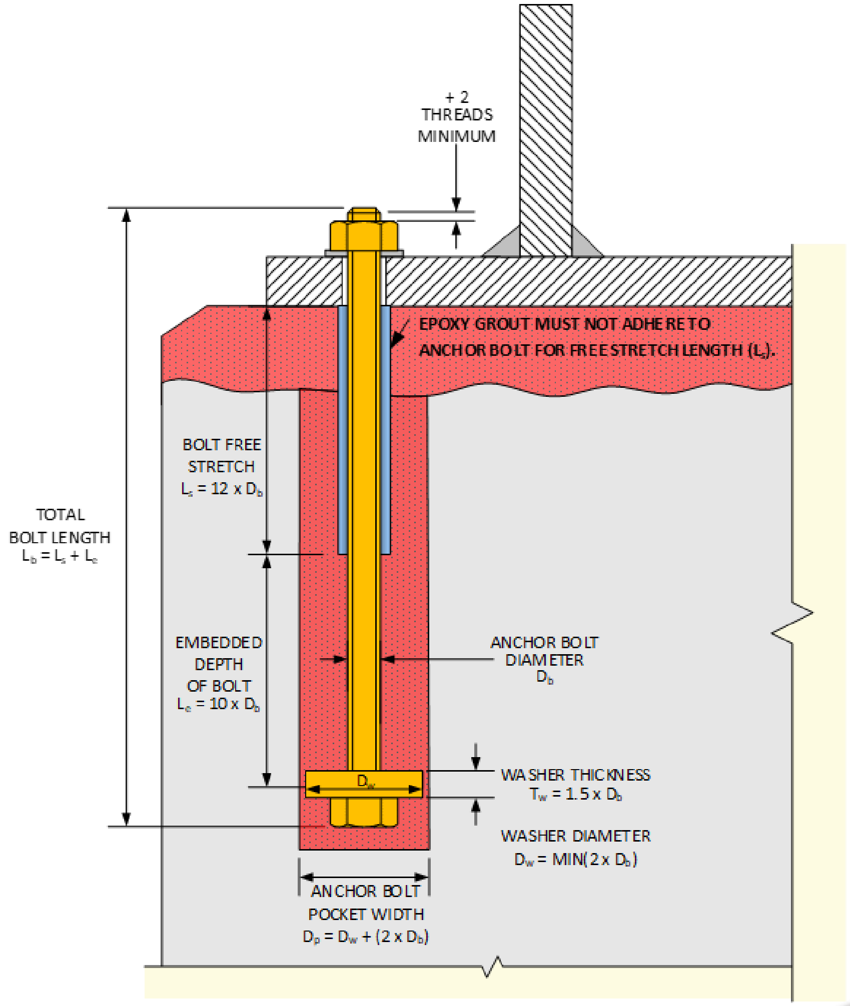
Plot of Vibration (in mils) vs. Base/Motor Position for a Weak Motor Base[1]

Solution Design / Objectives of Solution Design

- Add rigidity to the skid frame
- Use anchor bolts to connect the frame to the foundation system
- Support beams and load areas of the skid with epoxy grout
- Complete as much surface preparation as possible with compressor remaining in place and connected to surrounding process equipment during scheduled downtime

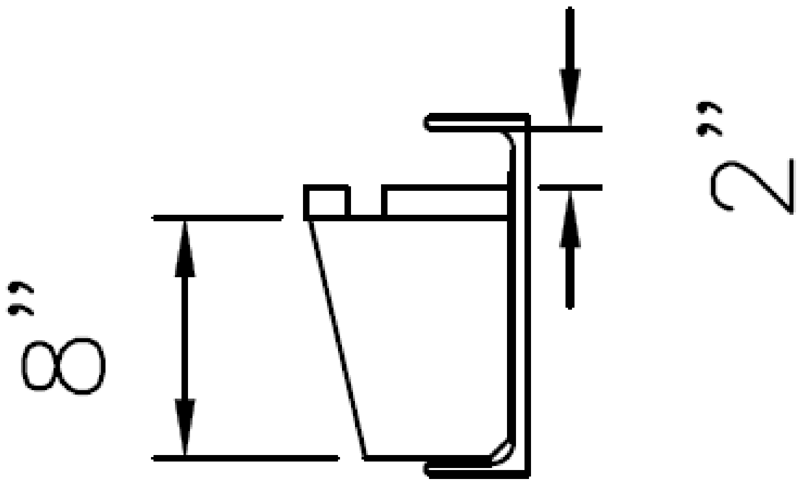
Solution Design / Challenges Considered by Solution Design

- Anchor Bolt Best Practices
  - Min. 12 bolt diameters of isolation for free stretch
  - Min. 10 bolt diameters of embedment in the foundation
- Limited Concrete 10-in (254-mm) Mat Thickness
- Congested area with compressor remaining in place
  - Filled entire cavity of skid over just around support beams



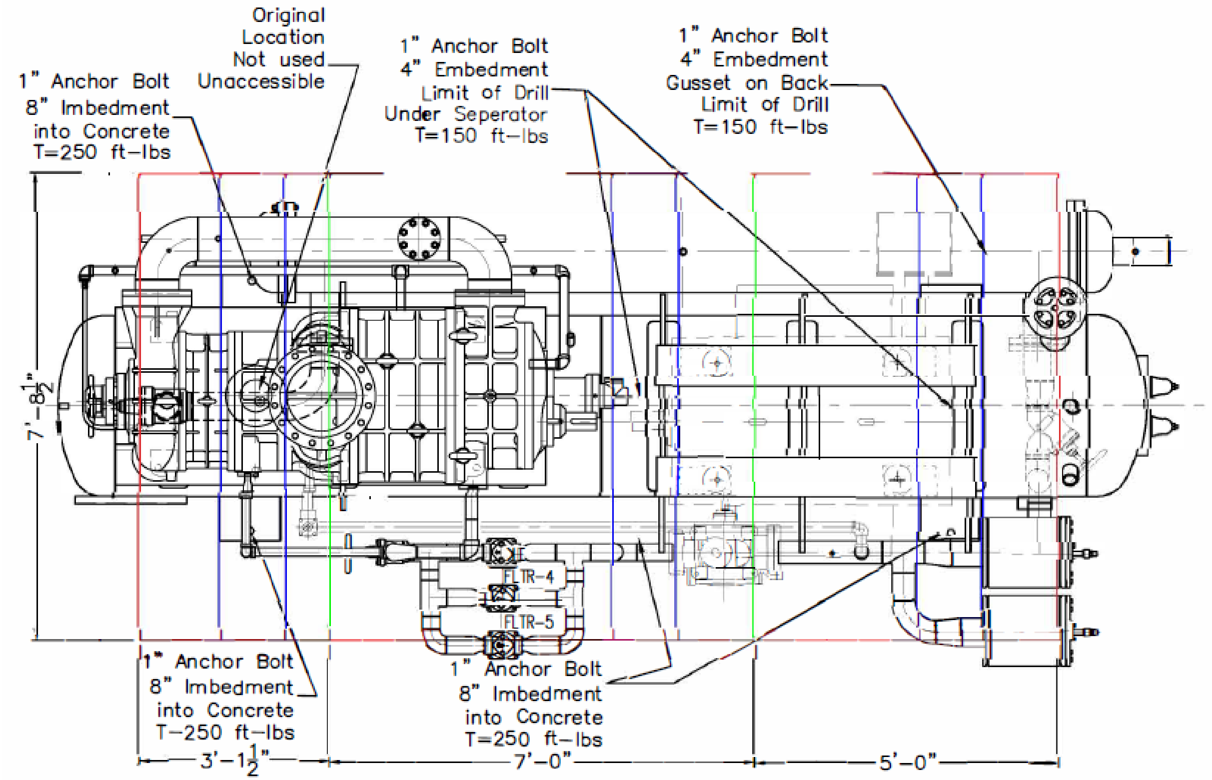
Solution Design / Challenges Considered by Solution Design

- To achieve effective anchor bolt stretch, anchor bolt chairs to be welded to the existing compressor skid frame.
- Standard chemical anchors used to secure bolts to the existing concrete foundation.



Executed Solution / On-site Process

- Drill anchor bolt holes as deep as possible
  - 1-1/8” OD hole for a 1” OD chemical anchor
  - Unable to achieve goal 8-in (203-mm) embedment for all anchors
- Weld anchor chairs to skid frame
  - Hang new anchors from chairs until and apply chemical anchors



Executed Solution / On-site Process

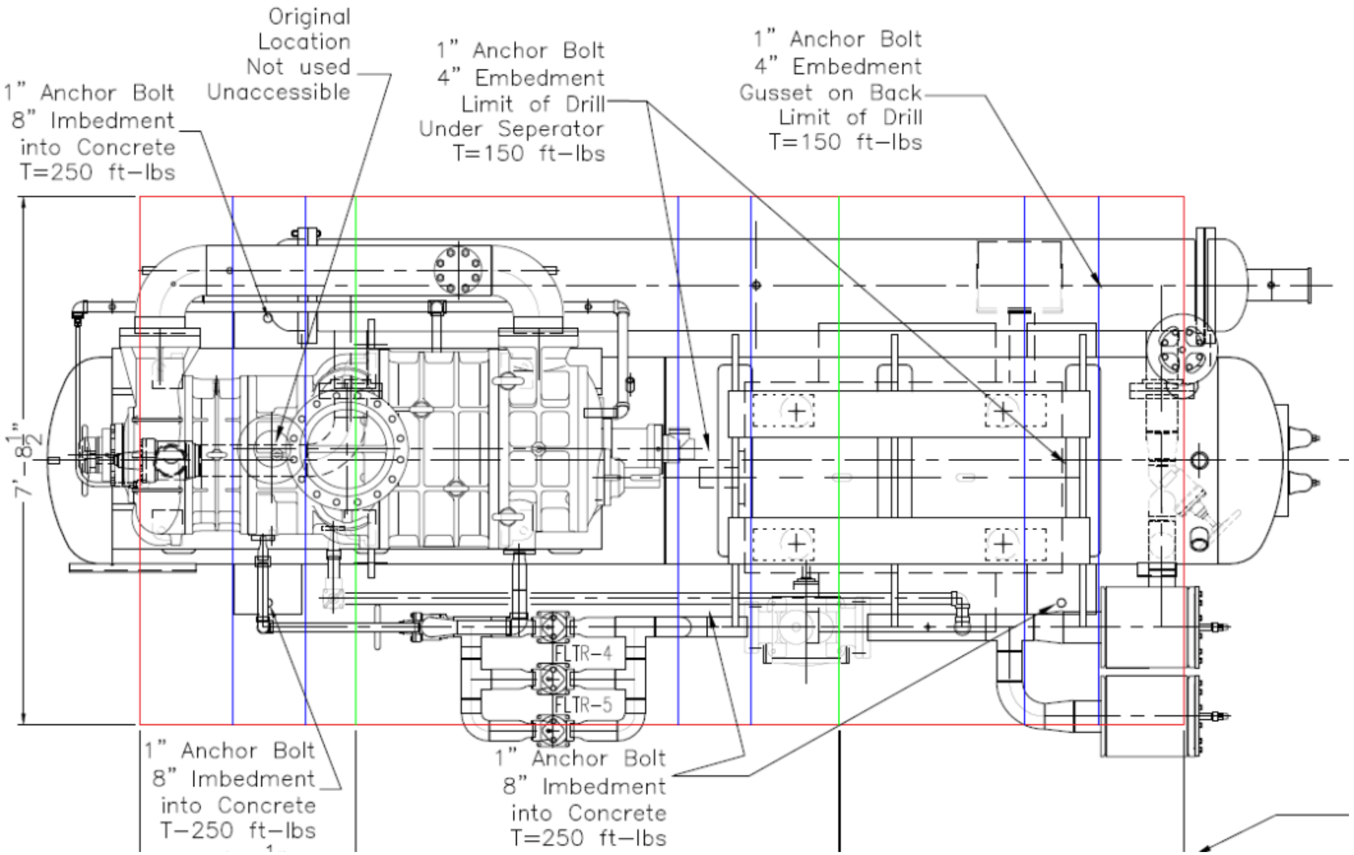
- Initial pressure wash and degreasing of frame
- Prepare concrete surfaces
  - Focused on beam-loaded areas
- Clean steel frame surfaces
- Install control joints

Executed Solution / On-site Process

- Mix and pour best-in-class epoxy grout under primary load areas and structural frame
- Allow epoxy grout to cure

Executed Solution / On-site Process

- Tension anchor bolts
  - Calculated based on embedment depth achieved and bolt characteristics
- Fill control joints with a high-quality epoxy sealant
- Start up equipment and proceed with operation
- Total intervention completed within 5-day outage

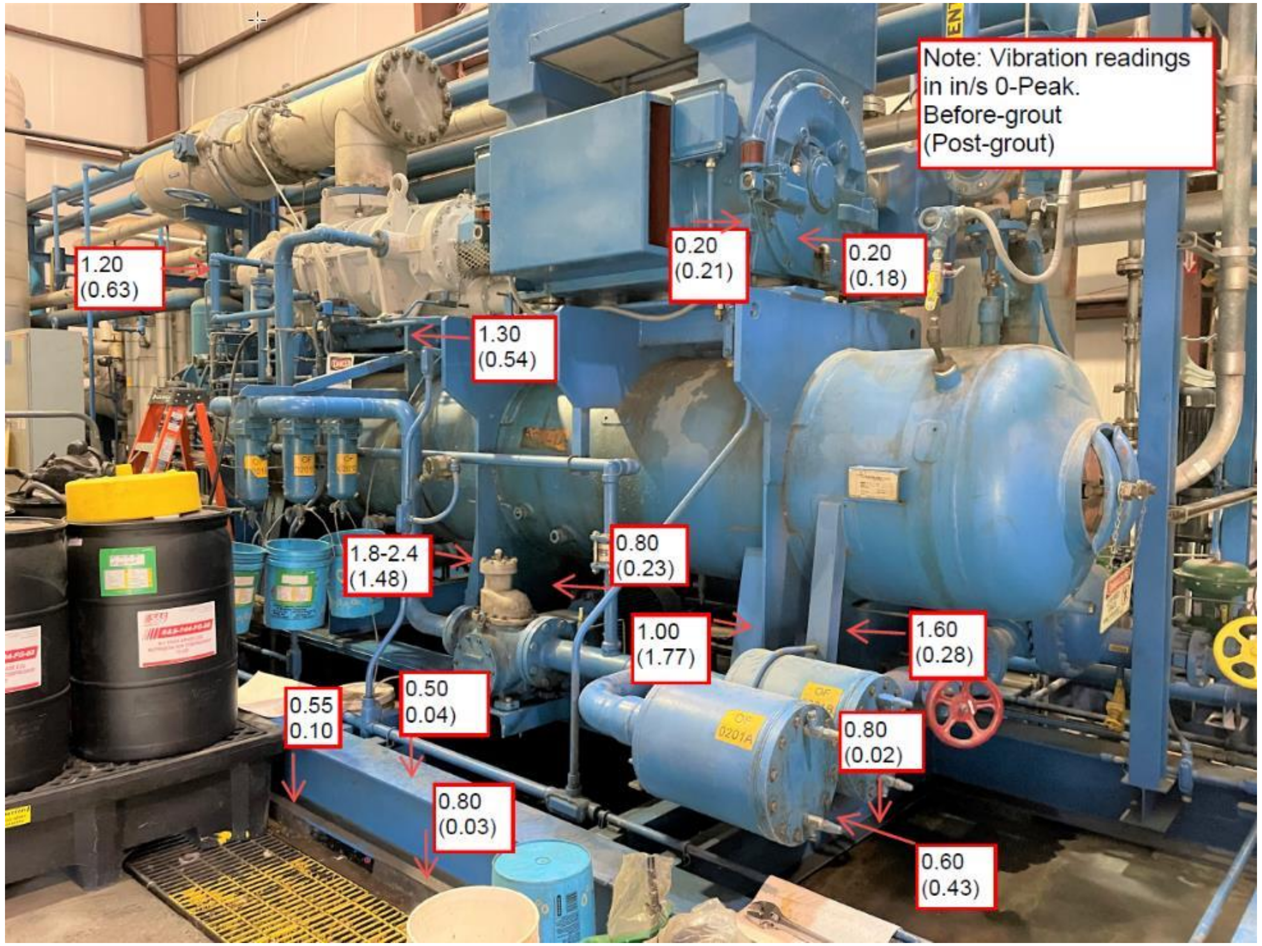


Outcome / Final Executed Solution Design

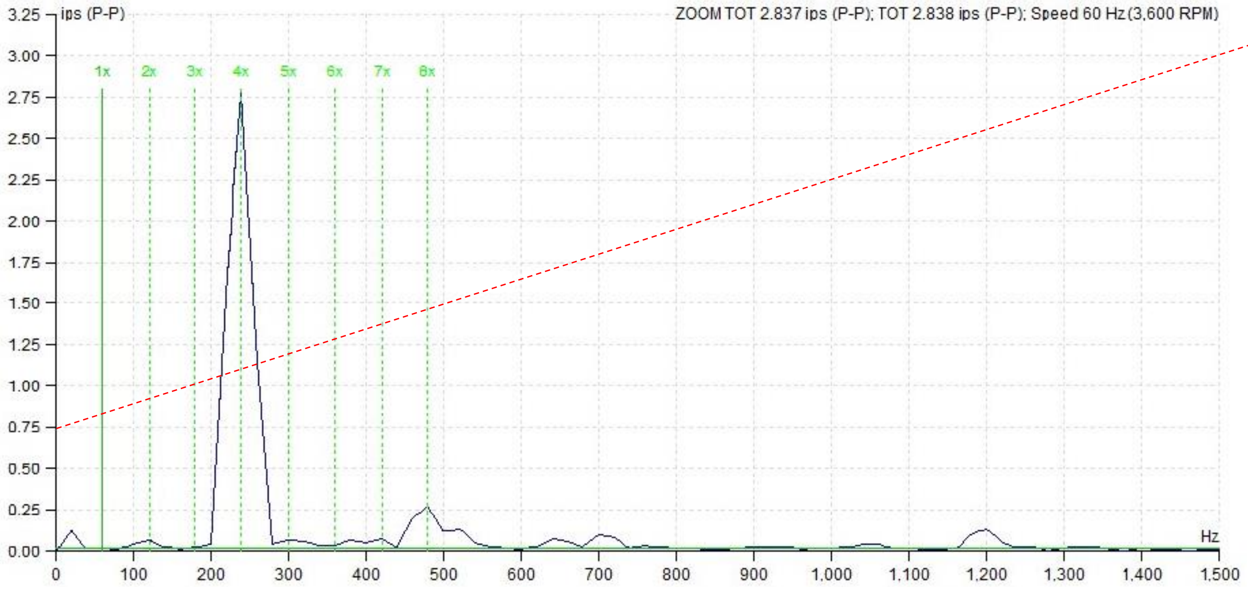
- Intervention completed while equipment remained in situ
- Epoxy grout added under primary frame support members
  - Added rigidity skid frame
  - Increased connectivity from equipment to overall foundation system
- Added 6 anchor bolts and tensioned
- Total intervention completed in 4 days

Outcome / Outcomes

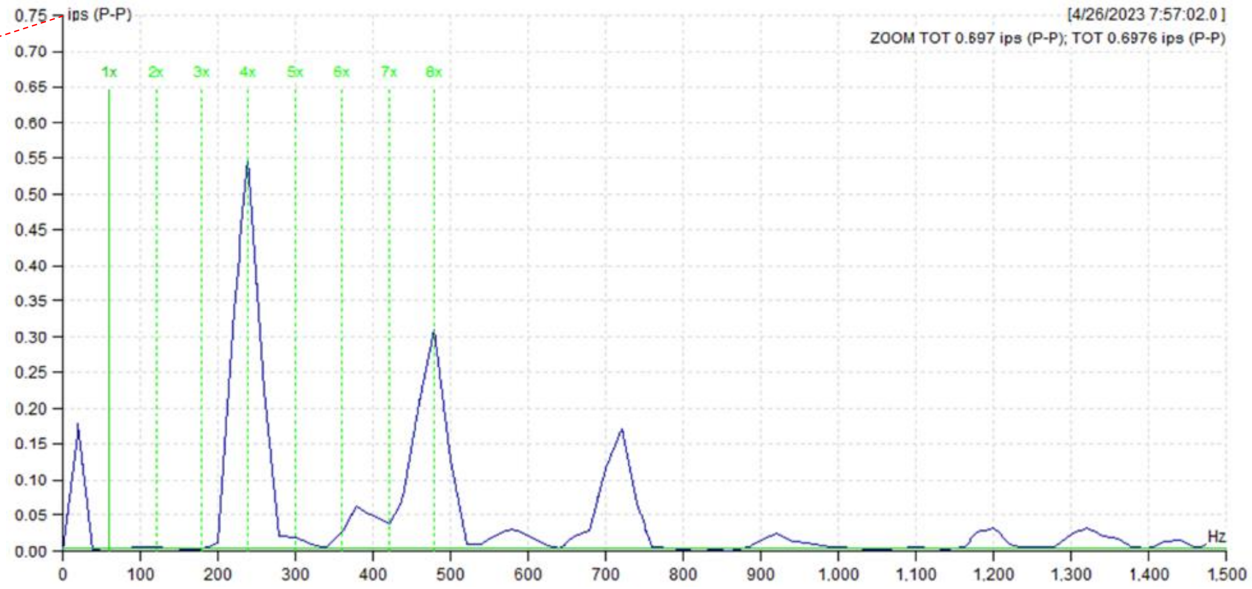
- Frame vibrations were re-evaluated post-grouting, indicating a substantial reduction.
- Considered a success due to:
  - Install execution
  - Vibration reduction
  - Conformance to current installation standards



Outcome / Vibration Results



Frame Vibrations Measured before Intervention

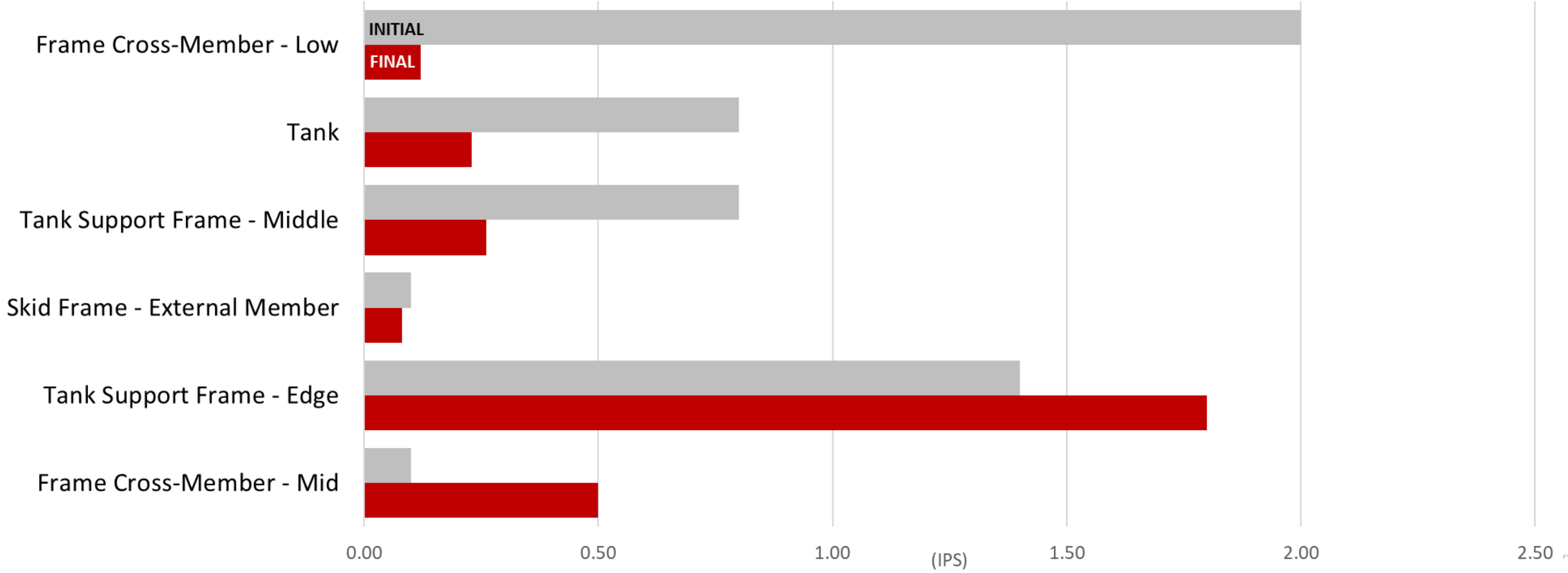


Frame Vibrations Measured after Intervention

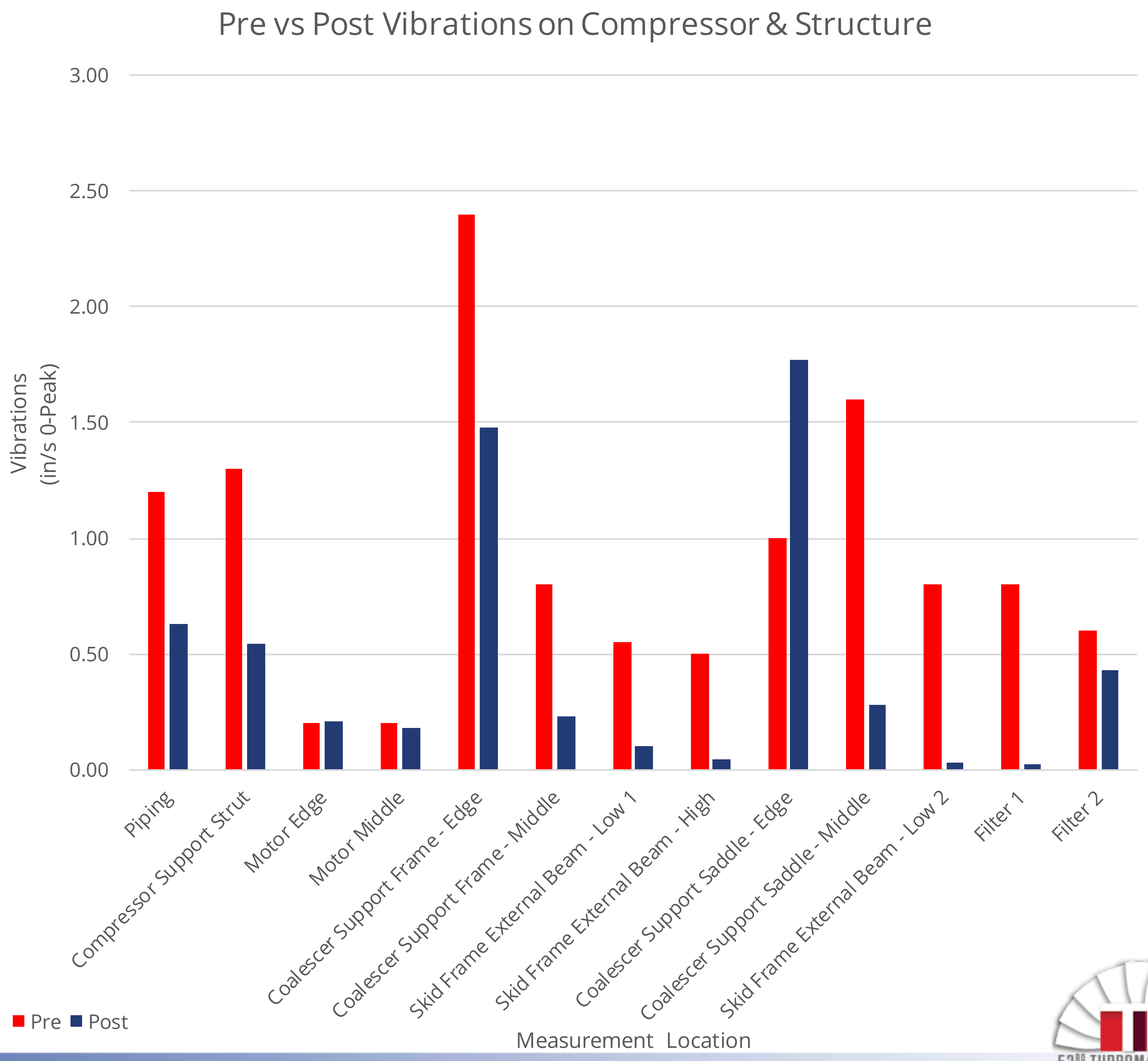
Outcome / Vibration Results

Overall Reduction

Comparing vibrations before and after intervention at key locations



Vibration Results



Key Lessons Learned from Intervention

- Collaboration was key to solution development.
- On-site support and assistance invaluable for keeping project on schedule.
- Foundation did not have adequate stiffness & mass to dampen vibration.
- Mass that existed not connected to over foundation system.
- Compressor not ideal to mount to top of skid.
- Significant improvement to operating environment even without following full specification.