High motor vibration on a screw compressor linked to natural frequency excitation.

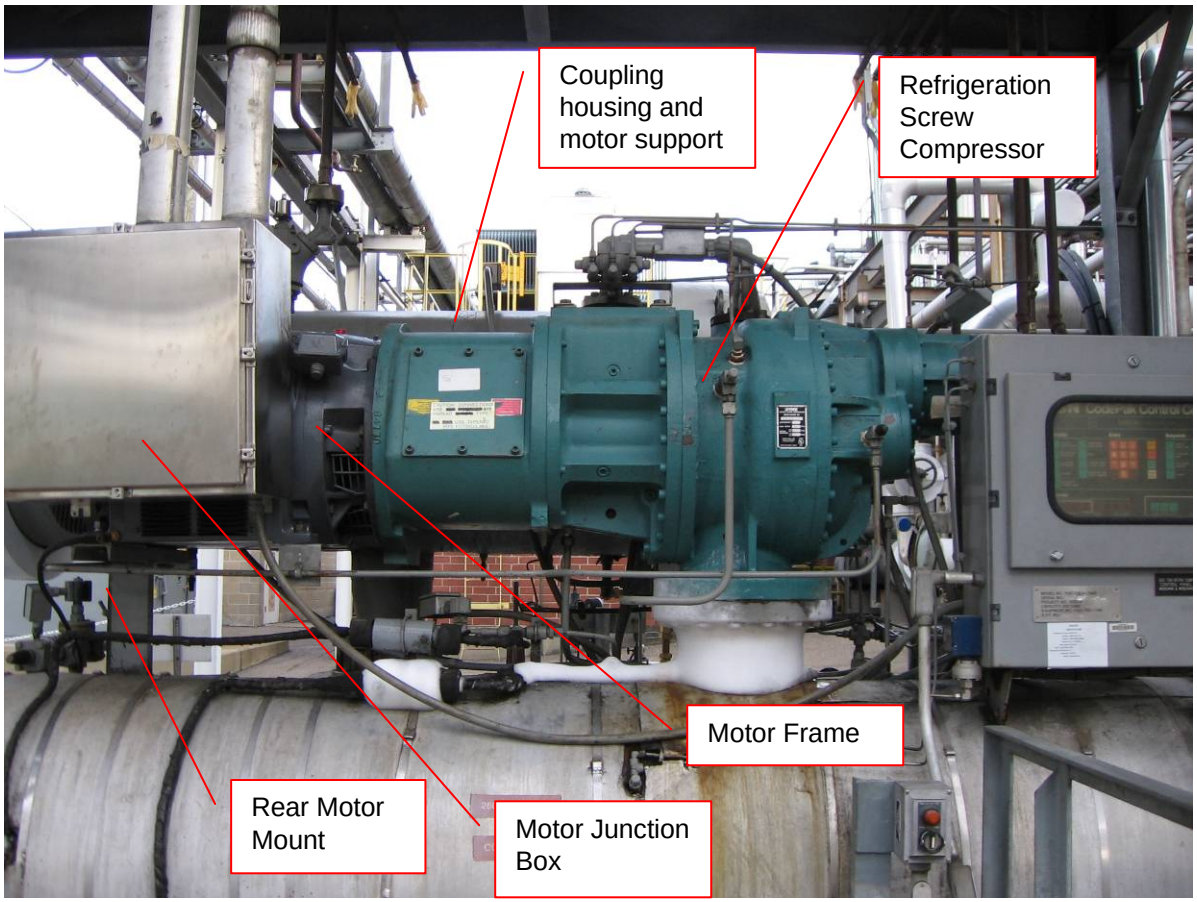
Matthew C. Taylor, P.E.
DuPont Washington Works
8480 DuPont Rd.
Washington, WV 26181
(304) 863-2757
Matthew.C.Taylor@usa.dupont.com

José A. Vázquez, Ph.D.
DuPont
Chestnut Run Bldg 722/RM2016
P.O. Box 80722
Wilmington, DE 19880-0722
(302) 999-6739
Jose.A.Vazquez@usa.dupont.com

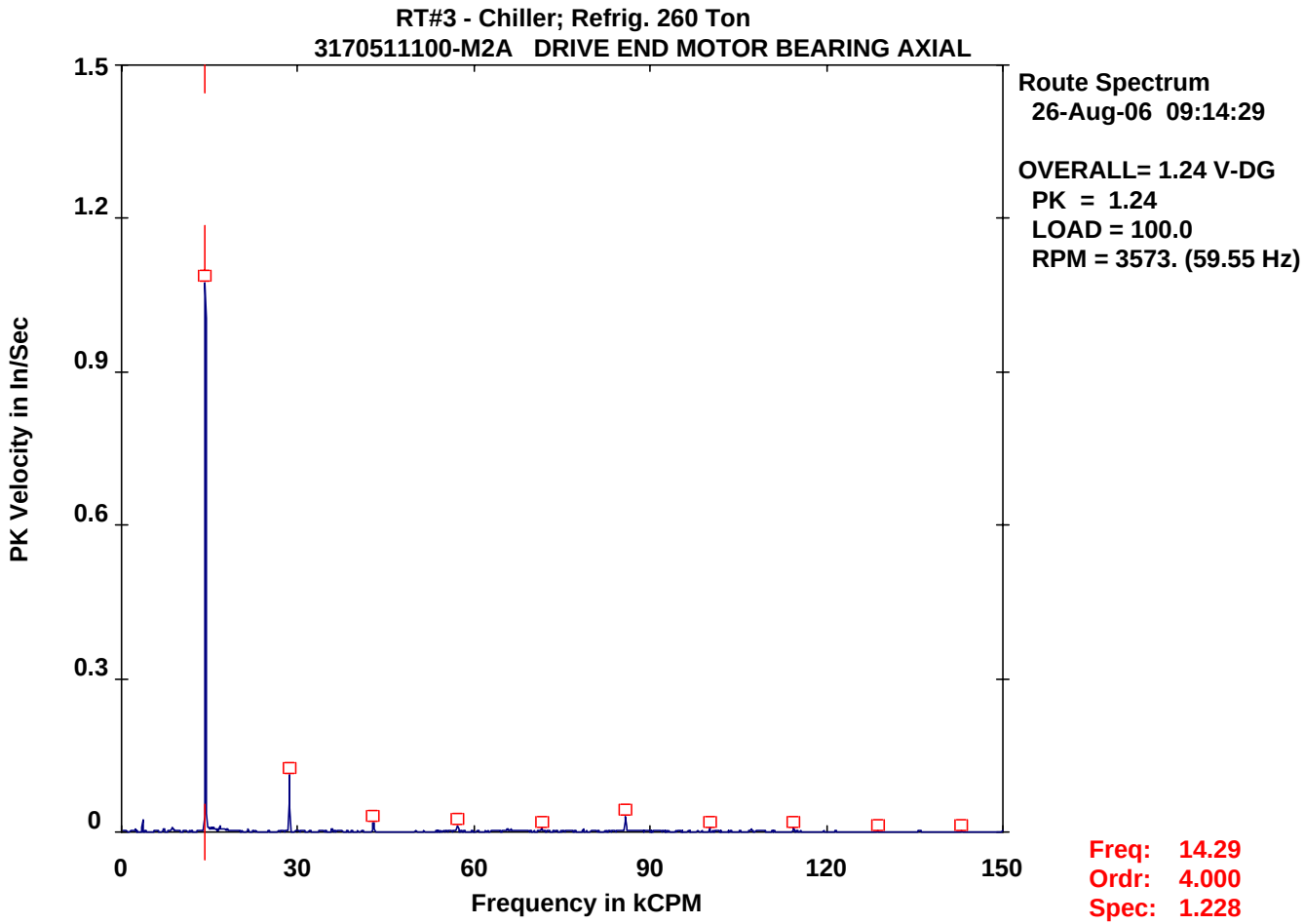
Problem Statement

- 260 Ton refrigeration screw compressor
- Compressor is mounted to the tank through the suction piping.
- Motor is flange mounted to the compressor through a bell that houses the flexible coupling.
- Additional support from the tank below, supports the rear feet of the motor
- After replacement of the screw compressor with a factory-rebuilt unit, routine vibration data sampling showed axial vibration at the motor frame in excess of 1.2 in/sec at 4X motor speed.
- 4X frequency of vibration coincided with the compressor lobe pass frequency, vendor was unable to reduce this force.

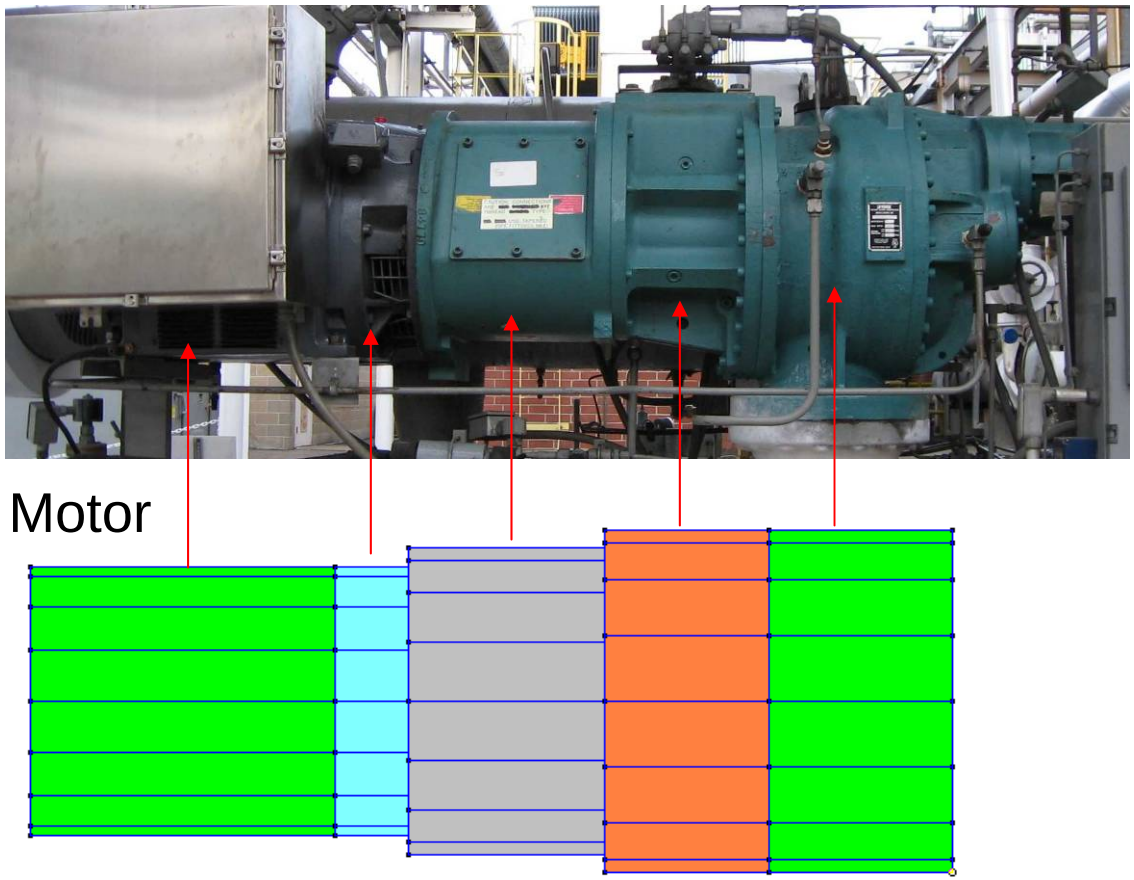
Refrigeration Screw Compressor



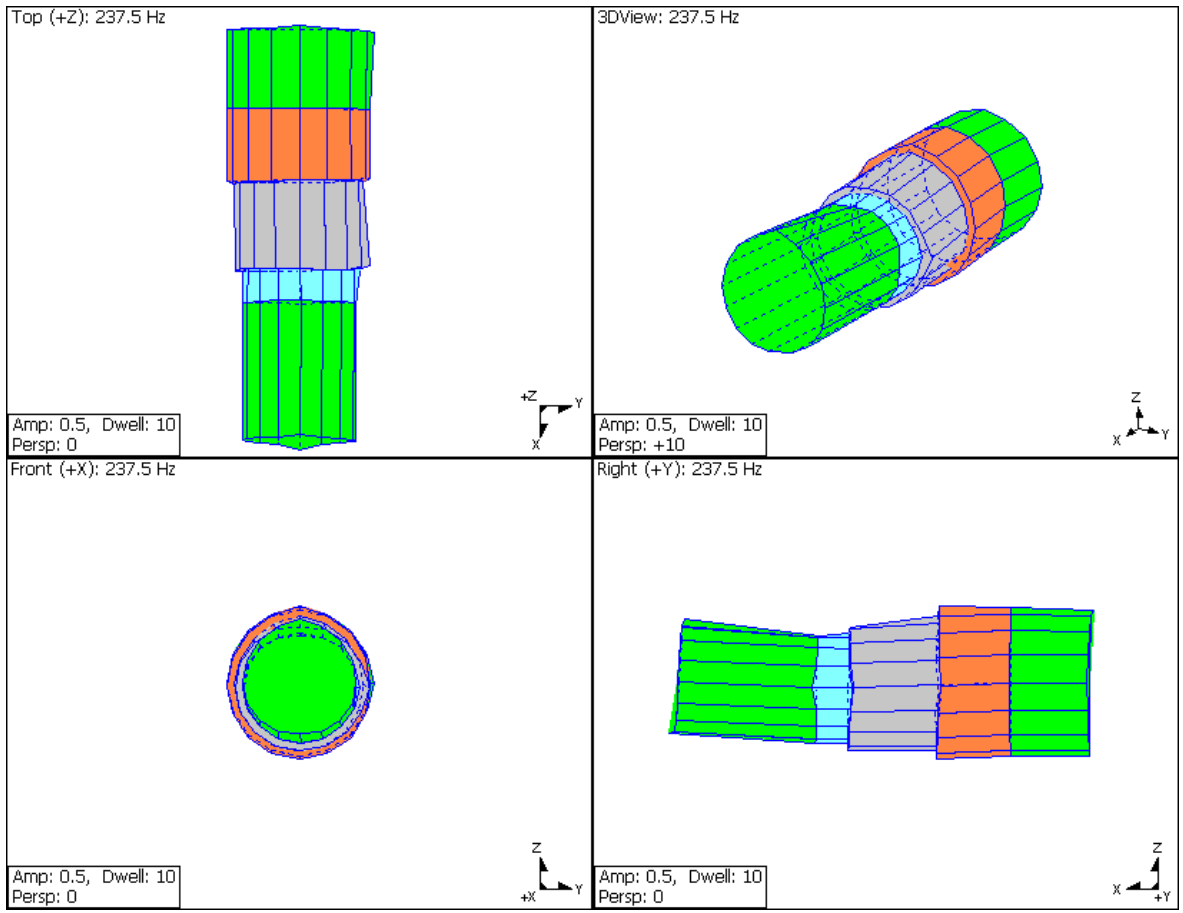
Axial Vibration at Motor



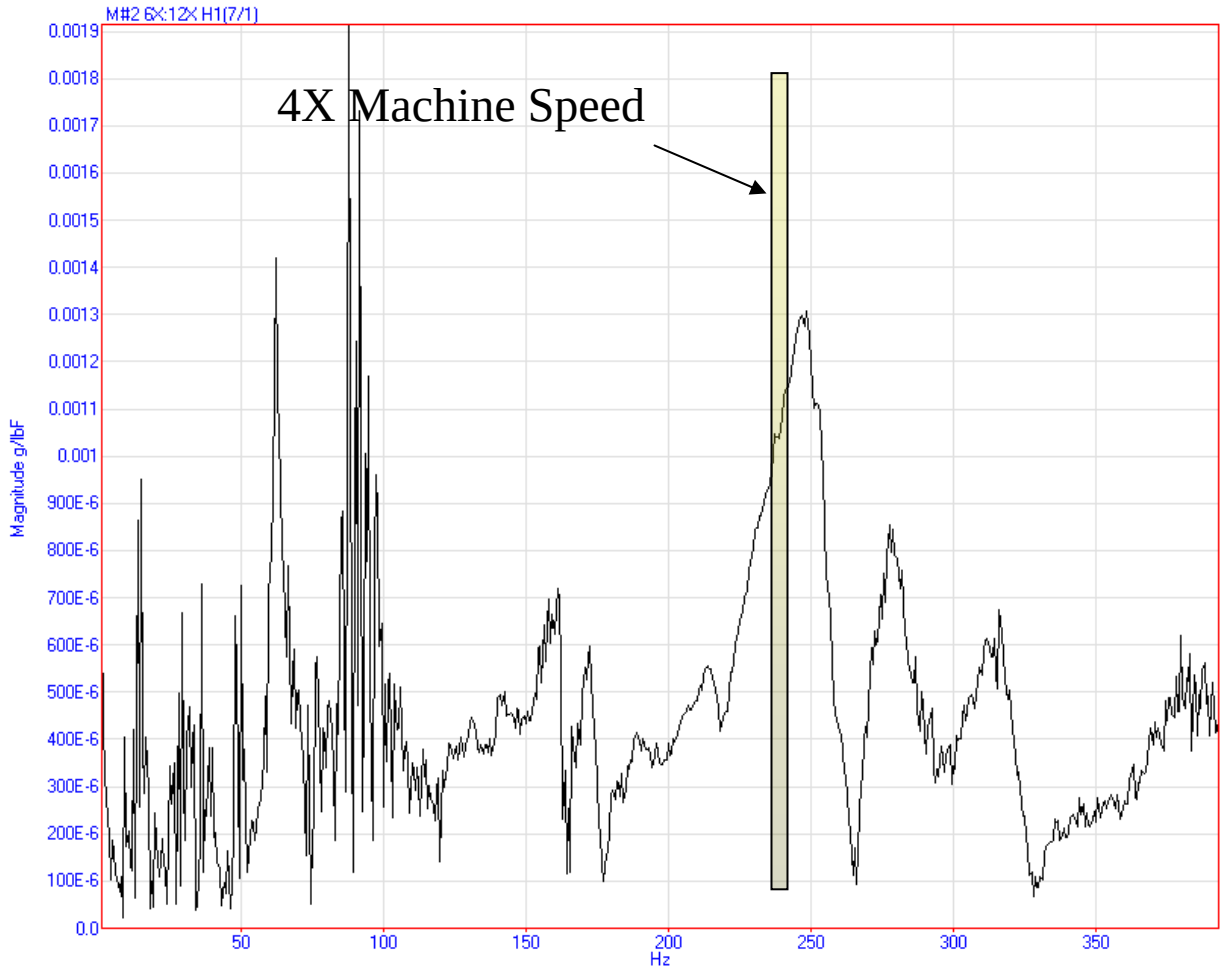
Performed Modal Analysis and ODS on the Machine



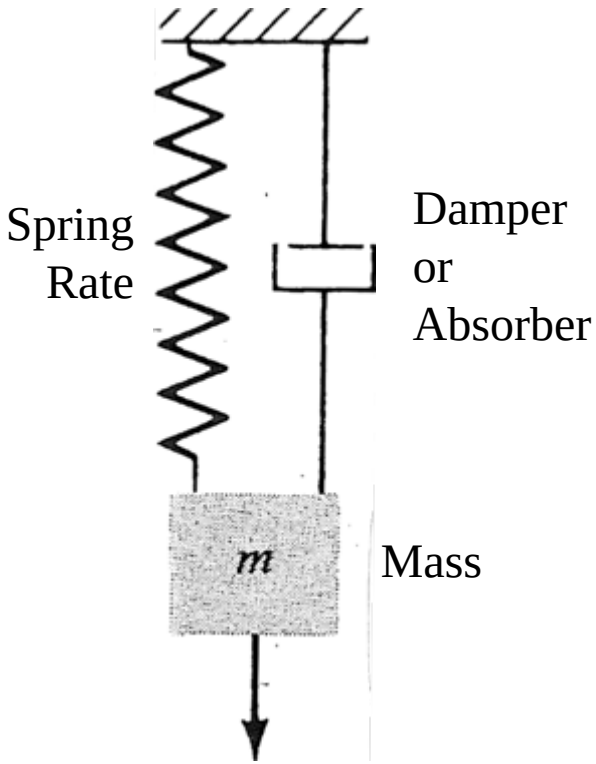
ODS Animation



Resonant Frequency



Vibration Theory

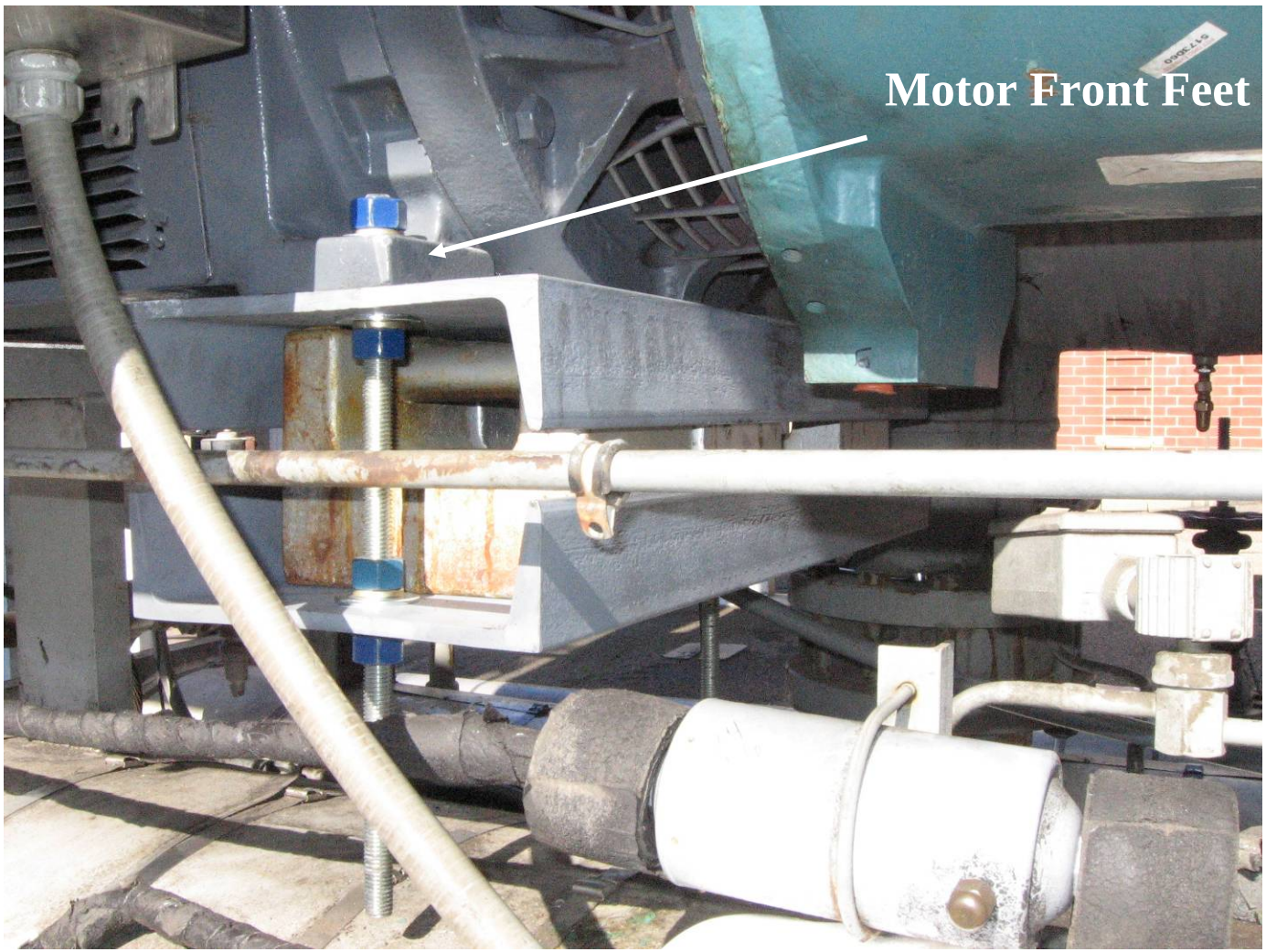


- All vibration systems have inherent resonant frequencies.
- To address a resonance,
  - Change mass of components
  - Change stiffness of components (spring rate)
  - Change damper or absorber

Trials to Address the Vibration Problem

- Added 150 lb at the motor to change mass. No significant effect.
- Not practical to stiffen the bell housing that supports the motor.
- Noticed that the bottom beam supporting the weights vibrated more than the upper beam. Tried a small vibration absorber using 4” flat bar, C-clamped onto motor housing. The results were promising, so designed a tuned absorber to the system resonance.

First Attempt: Added Mass



Added 150 lb to the motor feet for a test. No significant effect on vibration

Vibration Absorber Design Criteria

- Cantilever design using standard flat bar stock
- Carbon steel material
- Added weights for adjustability
- Easy bolt-on installation

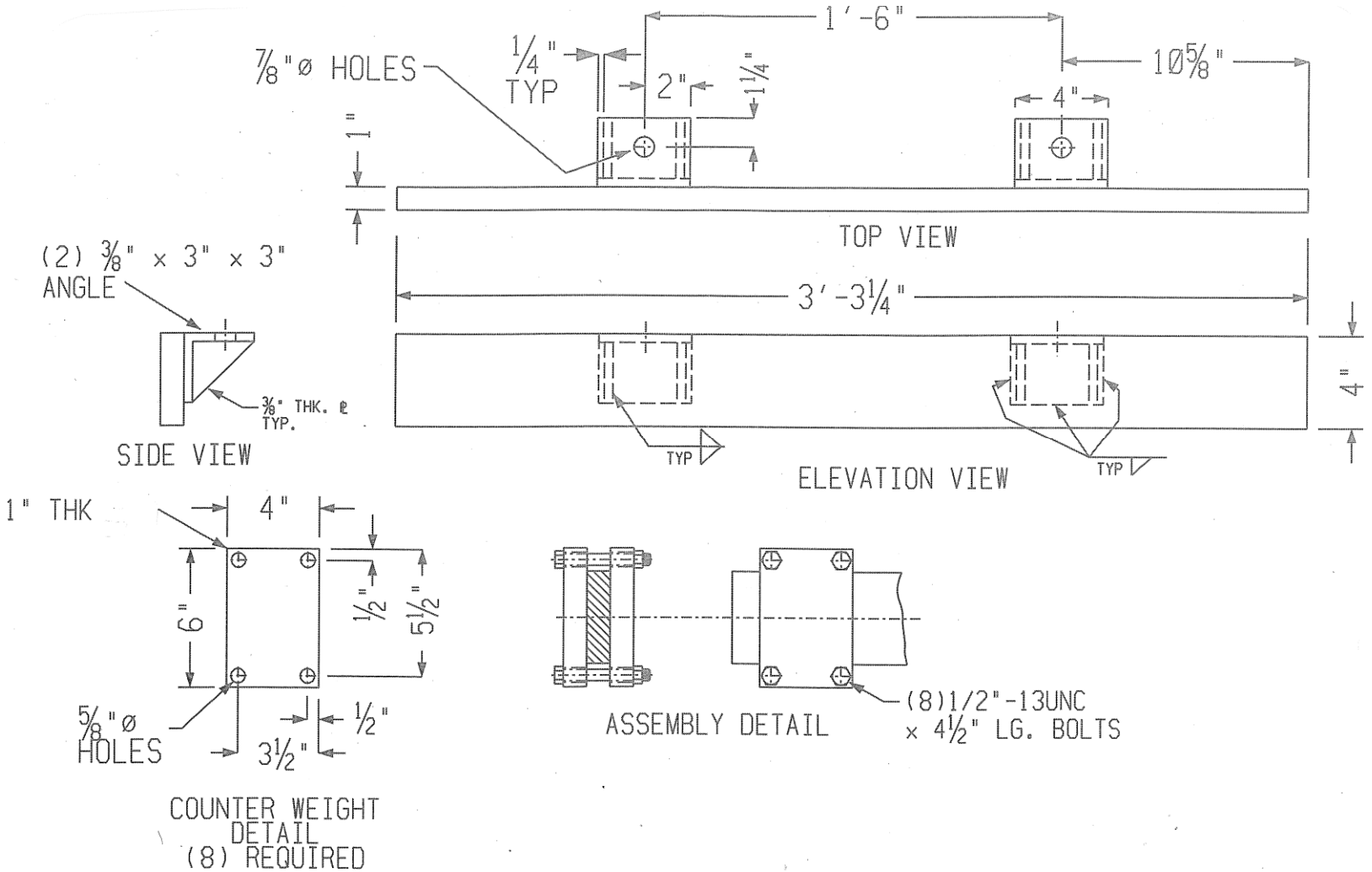
Major unknown:

- Boundary condition at the cantilever joint. Rigidity of the joint affect the natural frequency of the absorber

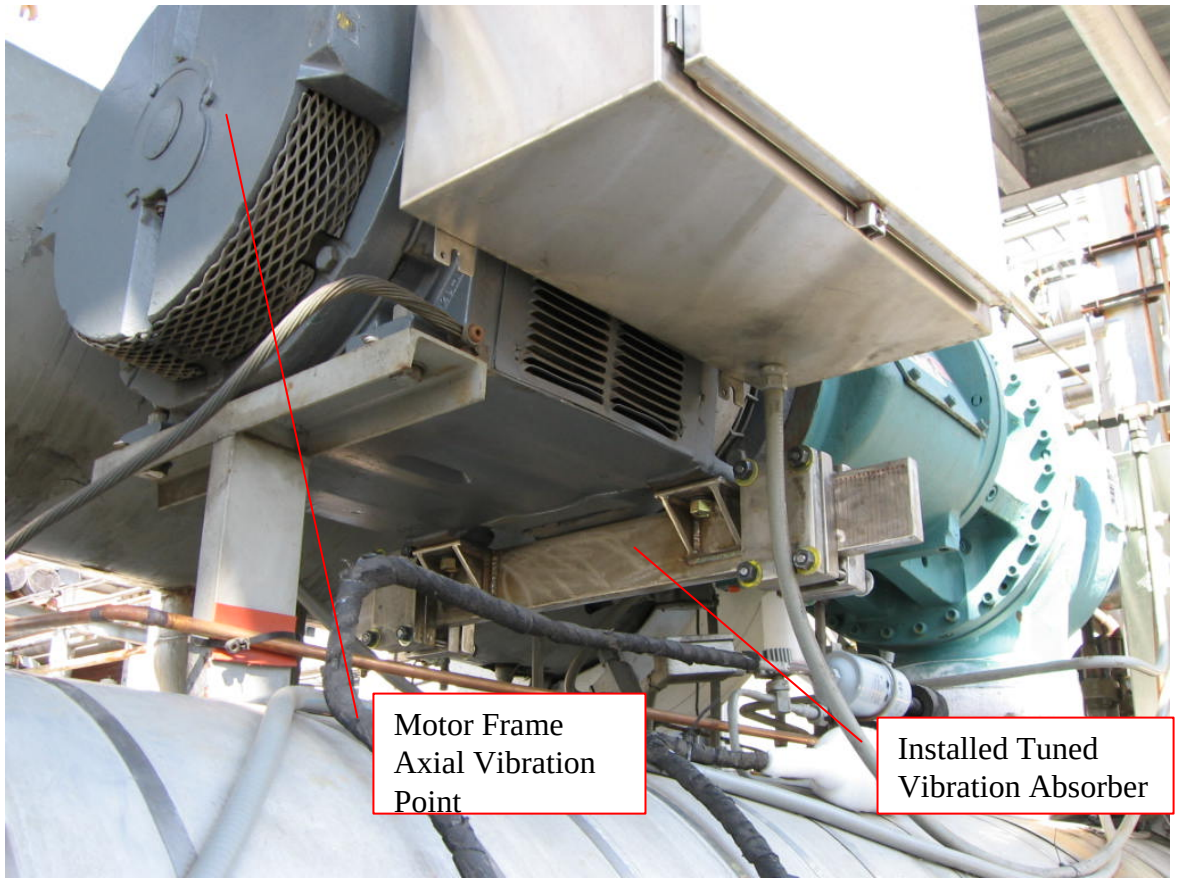
Vibration Absorber Design Criteria. Final design.

- Two cantilevers bars, one on each side of the motor. Dual bar helps minimize the effect of the cantilever joint.
- All-weather, stainless steel construction. This change from the original design had a large effect on the absorber frequency.
- Adjustable weights compensated for change of material but with a reduced absorption frequency range.

Vibration Absorber Design



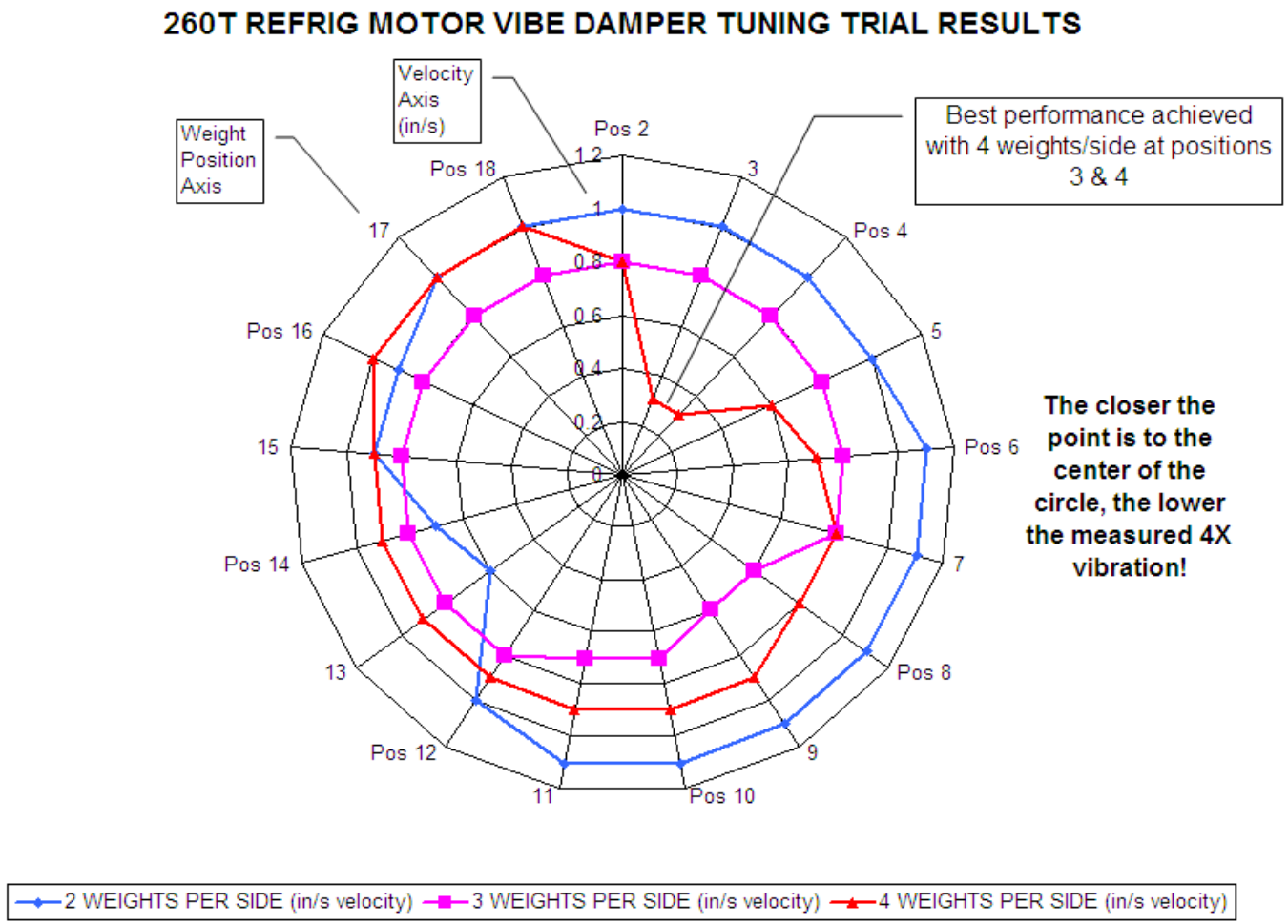
Vibration Absorber Installed on the Motor Feet.



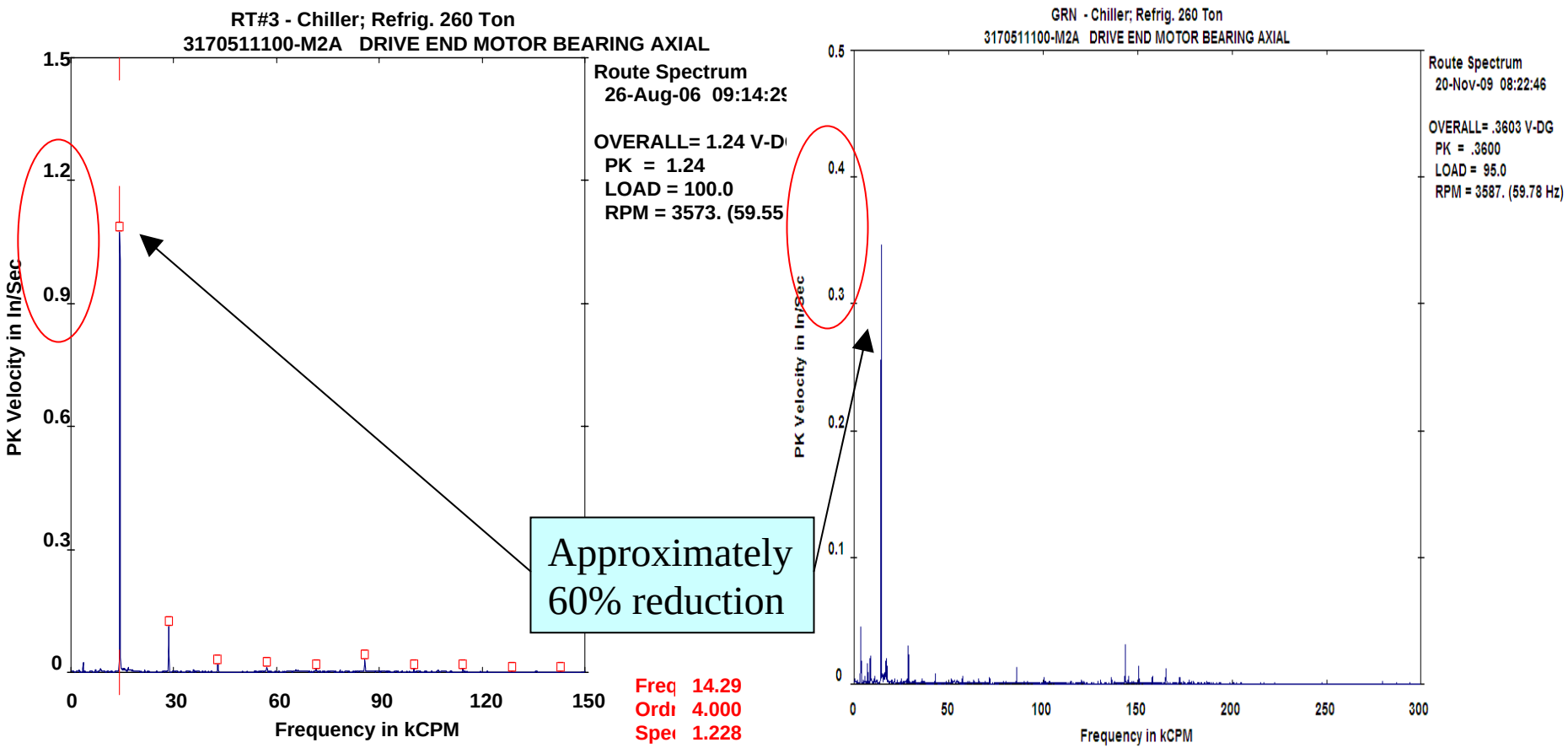
Vibration Absorber Optimization Trials

- Setup handheld vibration meter accelerometer on motor housing in “live” mode to see active spectrum.
- Marked each cantilever arm in ¼” increments.
- Placed 2, then 3, then 4 weights at each position and recorded max. reading at 4X frequency using handheld vibration meter.

Vibration Absorber Optimization Trials – cont'd



Final Results



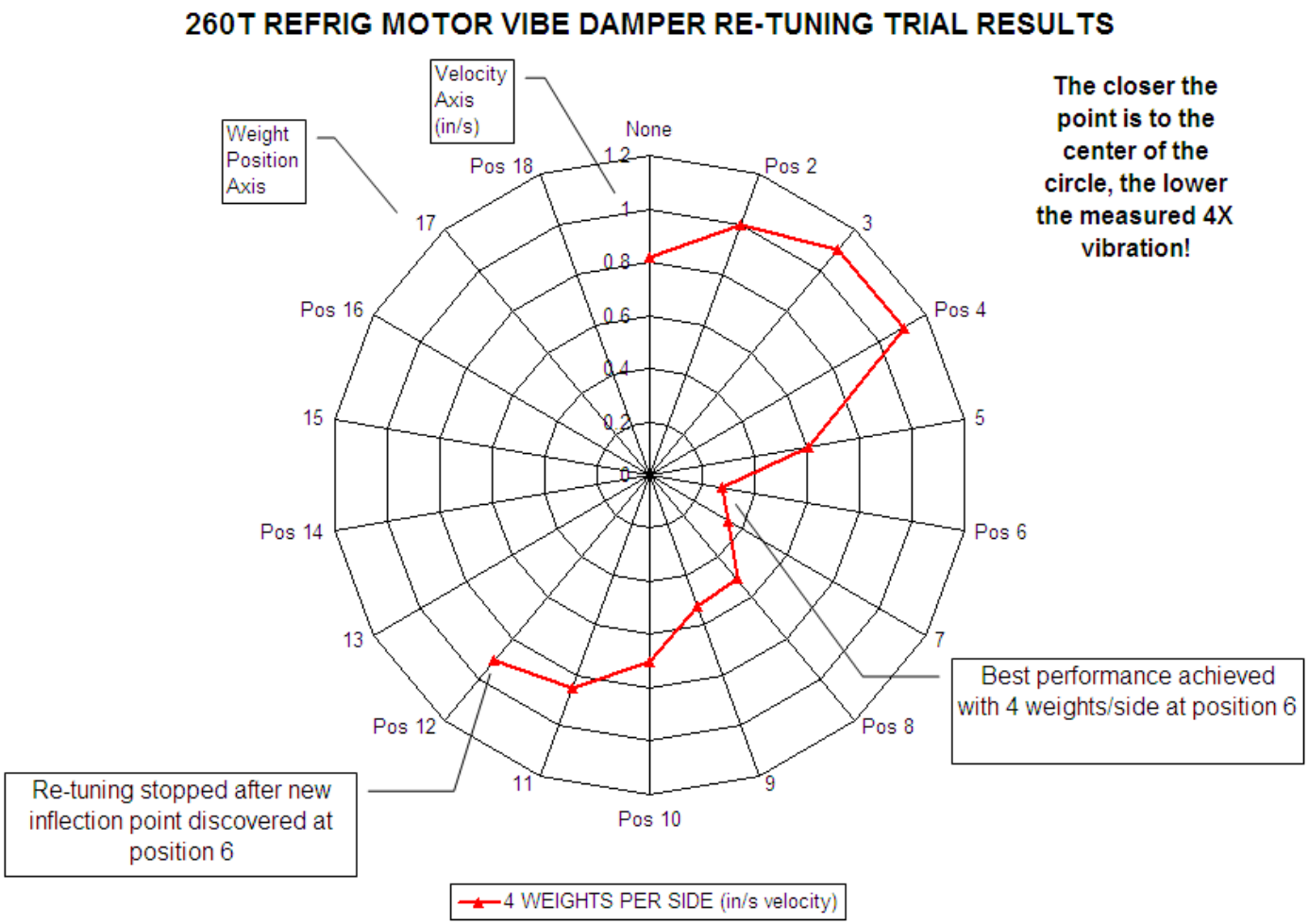
Issues & Future Actions

- Weights and weight positions provide tuning capabilities around a specific frequency, cannot automatically adjust to frequency changes.
- Absorber provides a “fixed” amount of absorption capability around the absorber frequency, cannot adjust to large excitation force changes.
- Although not perfect, absorber “softens” impact from destructive forces, extends motor life.

Retuning

- Due to 2009 economic slowdown and idling of production lines, load on screw compressor changed, motor changed rpm slightly (excitation frequency), had to retune absorber.
- Absorber retuning procedure
  - Remove weights & measure starting vibration.
  - Place weights at extreme inner or outer position.
  - Incrementally move weights and record resultant 4X vibration level.
  - Continue until a defined inflection point is found with minimal 4X vibration level.

Retuning – cont'd



Thank you for attending this presentation.

Questions?