Winter Vibration Problems on VS6 Booster Pumps and Solutions

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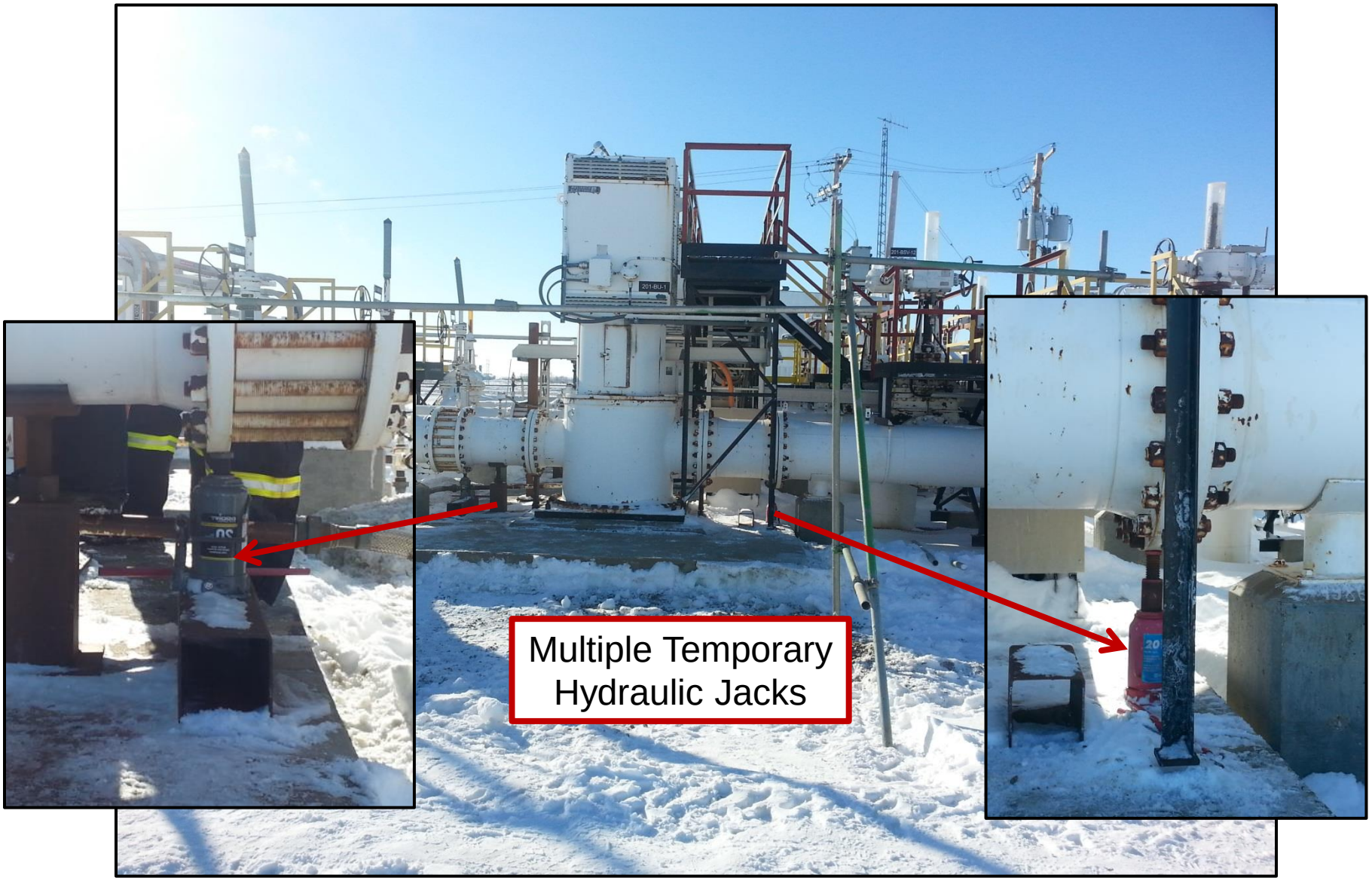
Background

- Three multistage canned vertically-suspended pumps are installed at Kerrobert, Canada to transfer crude oil.
- The pumps are driven by 1000 HP vertical motor at 885 RPM.

Problem Statement

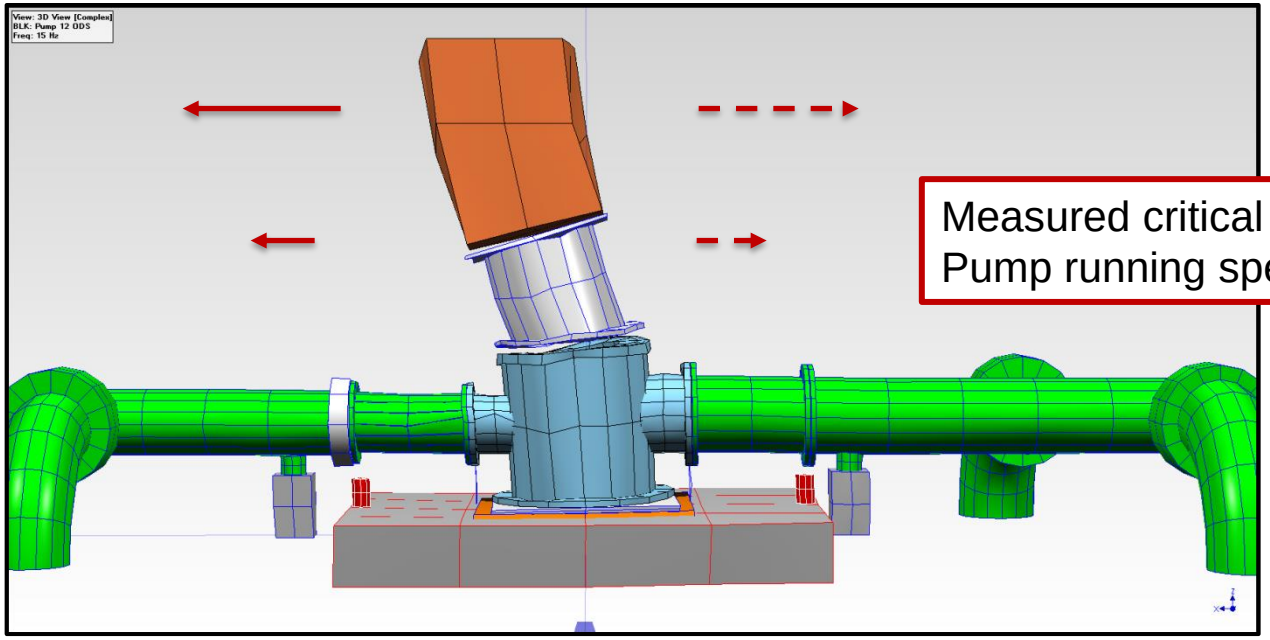
- The installed pumps vibrate in the winter but run fine the rest of the year.
- Several attempts to fix the problem at site did not yield success.
- After many years, the Pump User asked the Pump Supplier to analyze the problem.

Pump at Site



Field Study on Installed Pump

- Field vibration tests, including Operating Deflection shape (ODS) were conducted in the winter and again in the summer.
- These tests revealed the dynamic behavior of the pumping equipment in its installation including system piping.
- The results suggested certain modes of natural frequency were sympathetic to running speed only in winter.

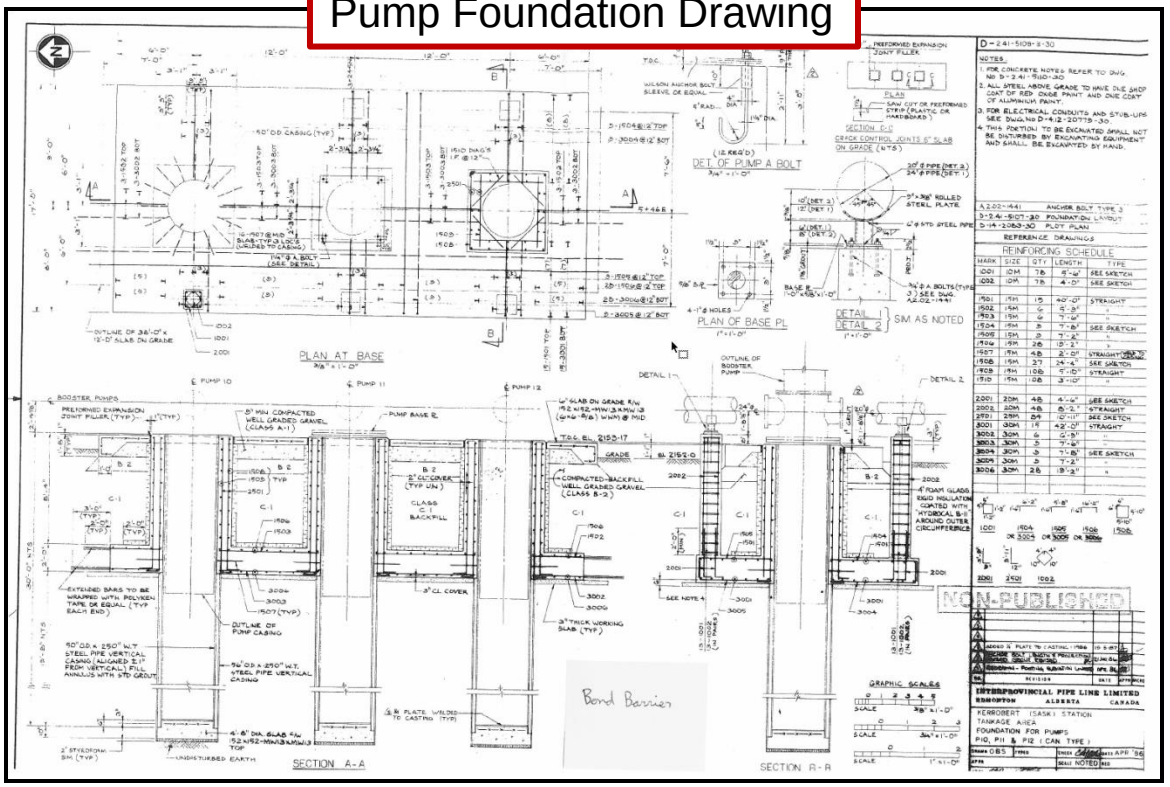


Measured critical mode just below 15Hz
Pump running speed 885 RPM (~14.75Hz)

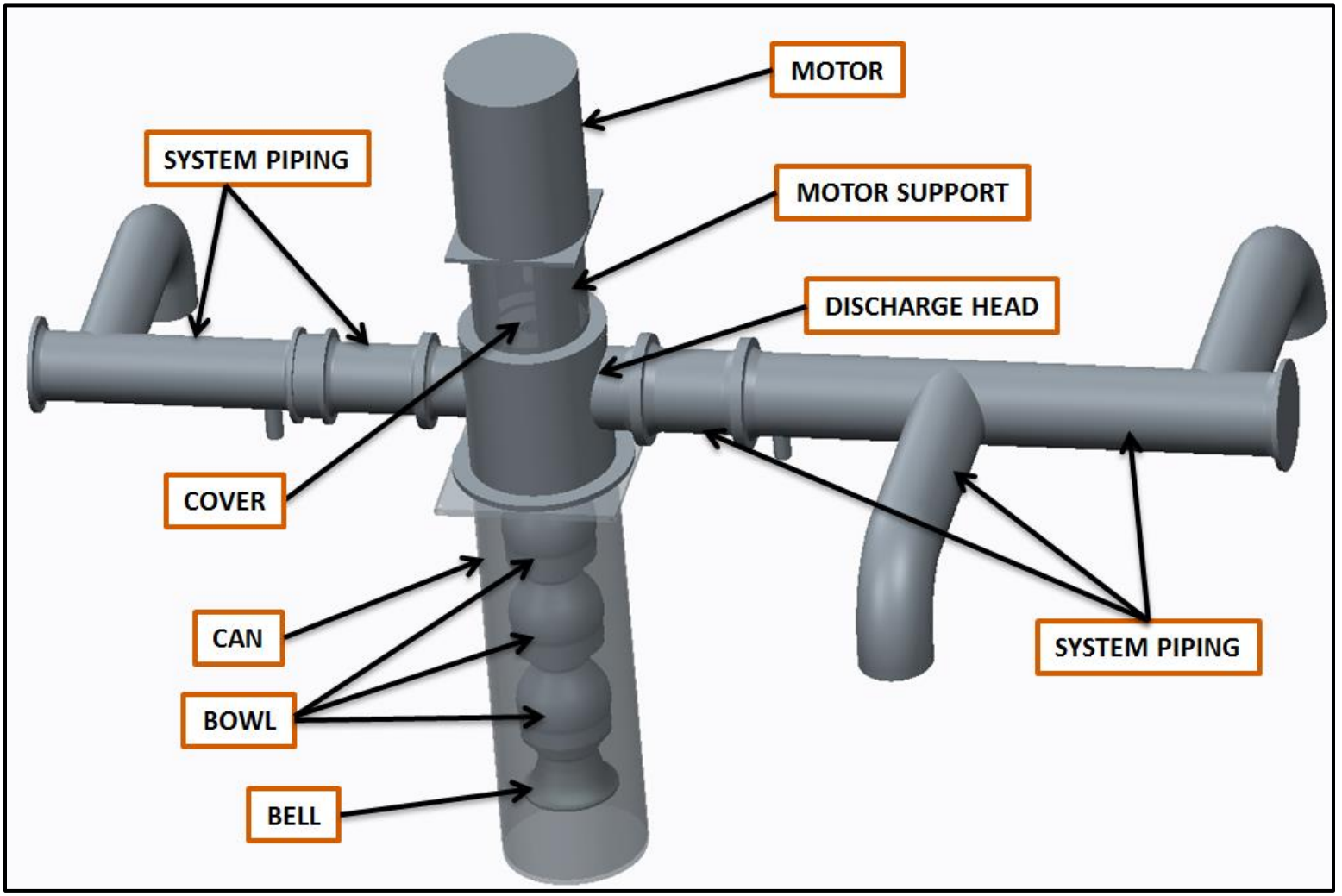
Possible Cause

- Considering high vibration amplitudes are seasonal, water freezing inside the pit which enclosed suction barrel was considered a possible cause.
- Review of pump foundation drawing revealed extra depth of the pit which supported freezing water theory.

Pump Foundation Drawing

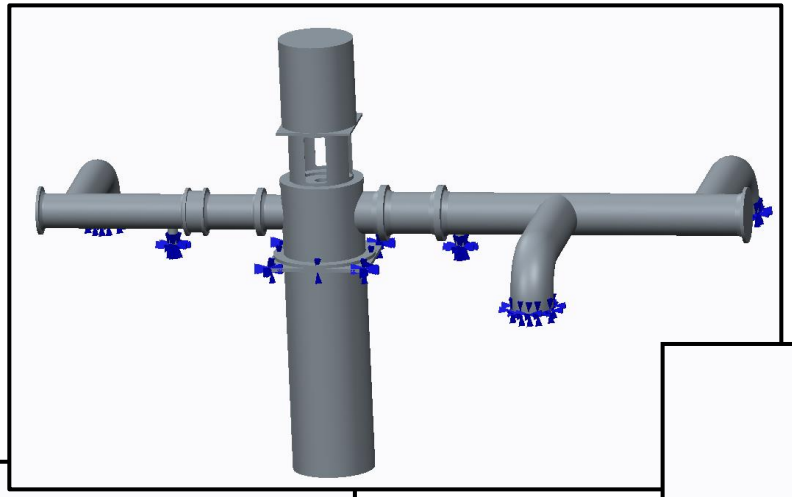


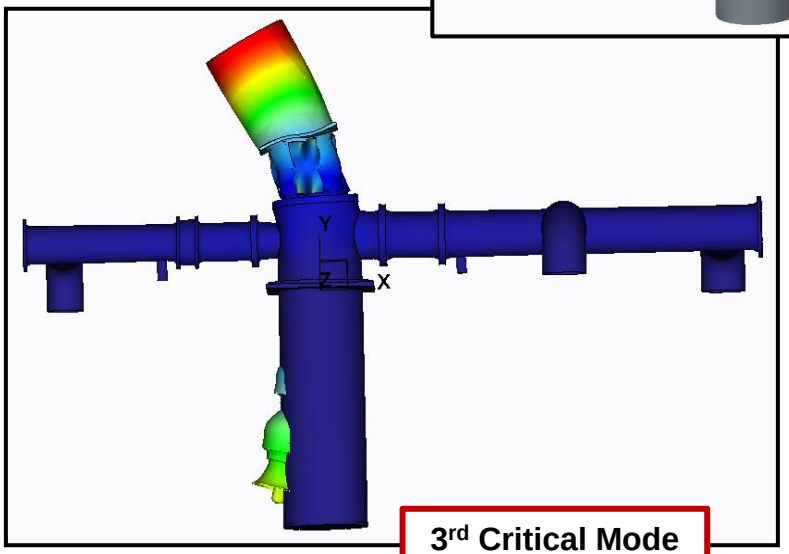
FEA Study – Model Setup



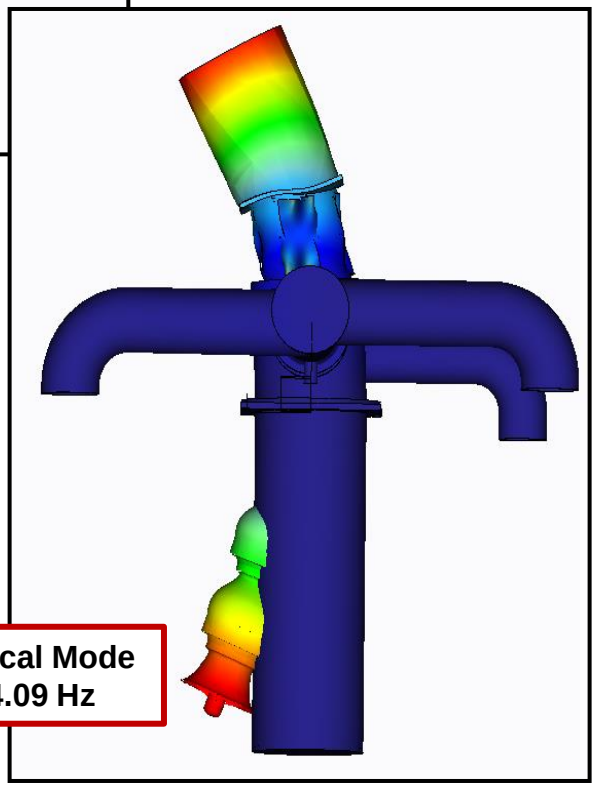
FEA Software : Creo Simulate 2.0

FEA – without Restraining Suction Can



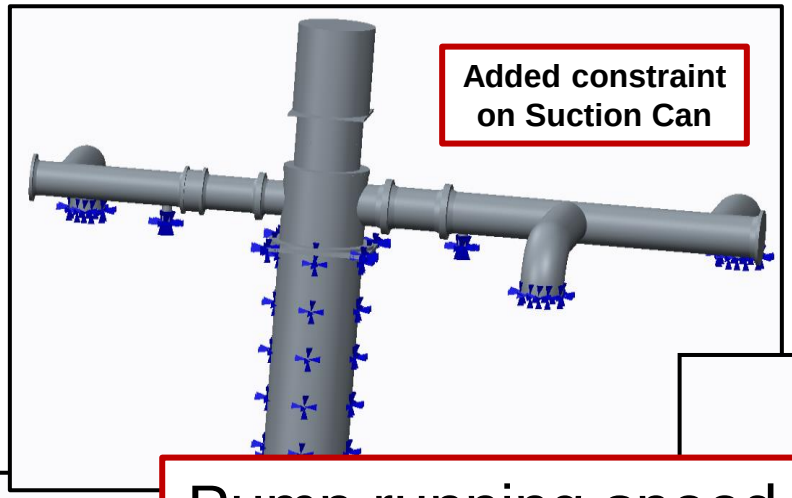


3rd Critical Mode
@ 13.60 Hz

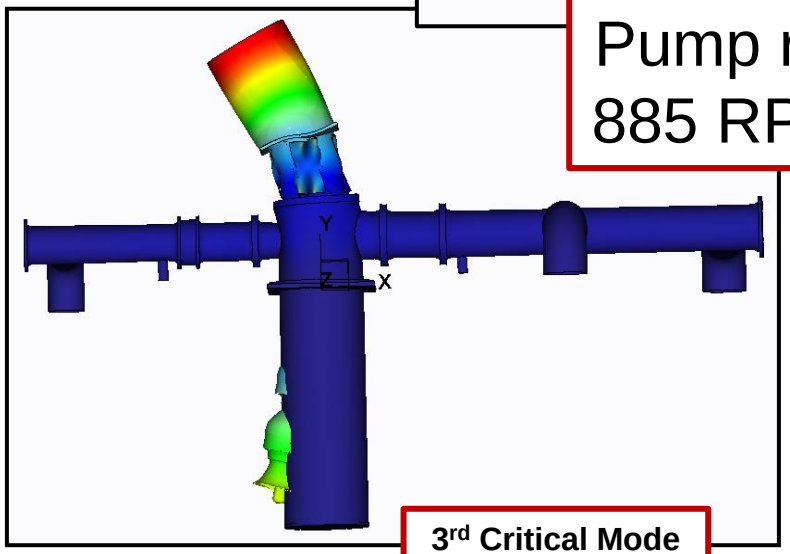


4th Critical Mode
@ 14.09 Hz

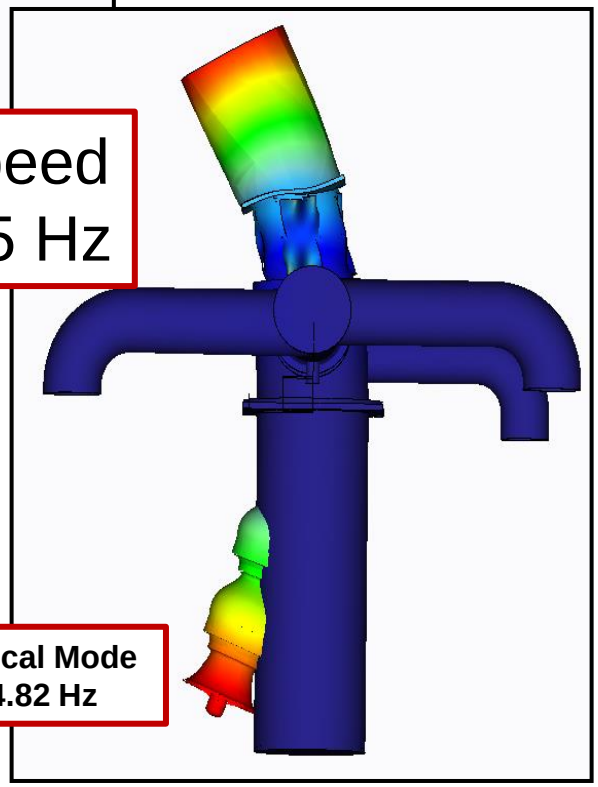
FEA – Restrained Suction Can (Ice)



Pump running speed
885 RPM = 14.75 Hz

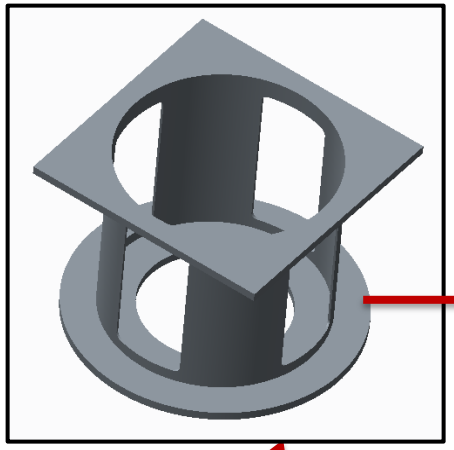


3rd Critical Mode
@ 14.39 Hz

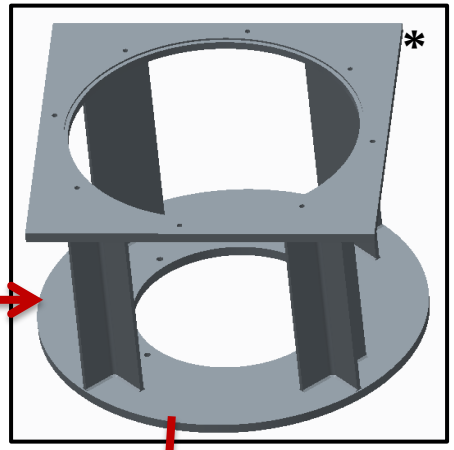


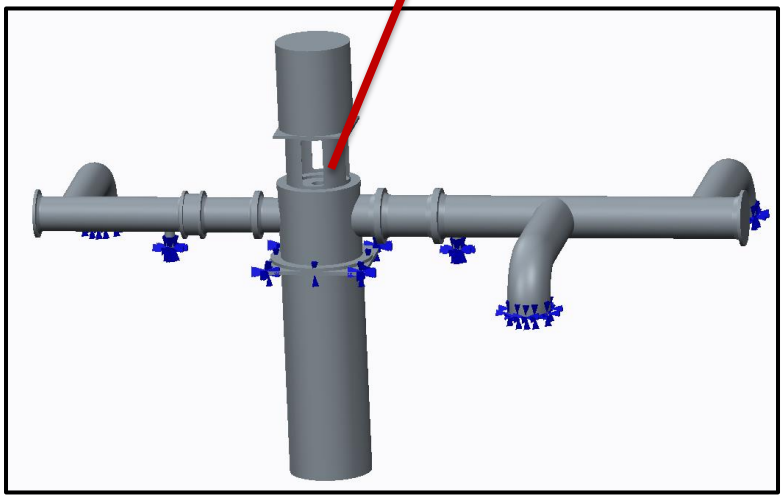
4th Critical Mode
@ 14.82 Hz

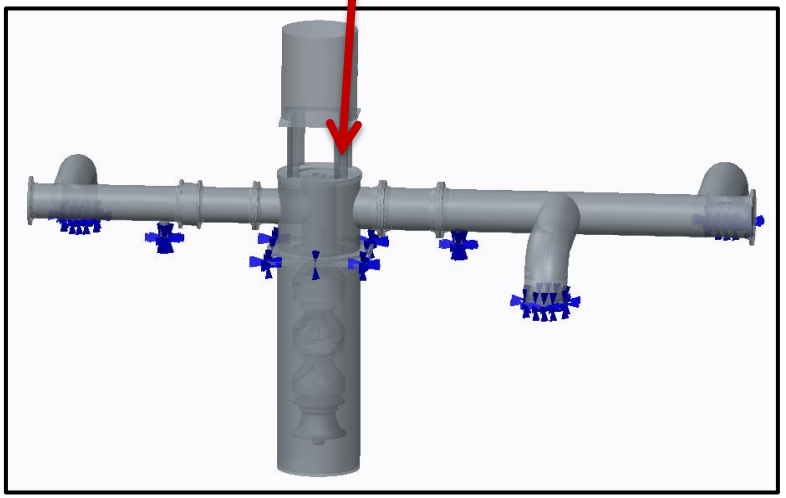
Innovative Design Modifications



New Motor Support Designed to make structure more flexible

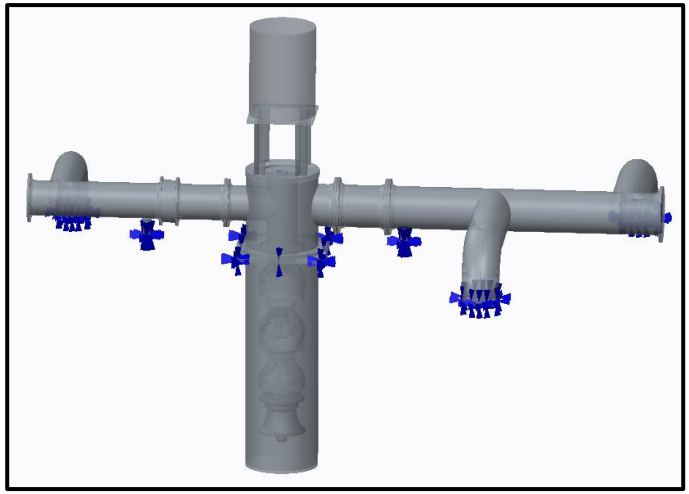


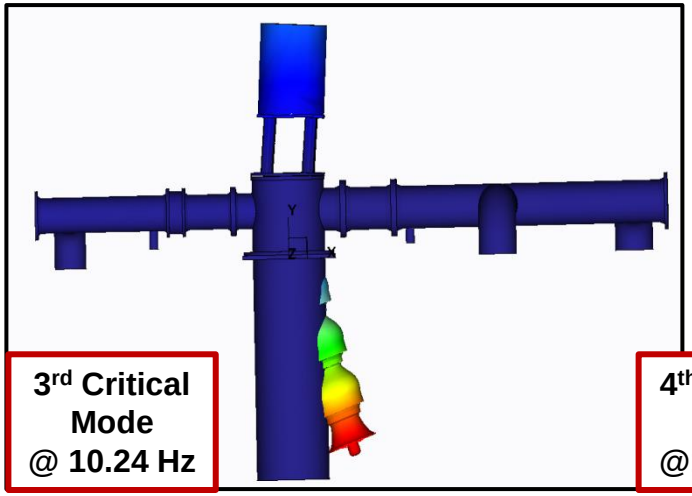




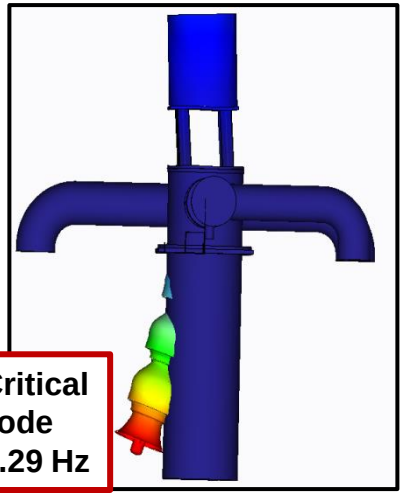
*patent pending

FEA Study with New Motor Support

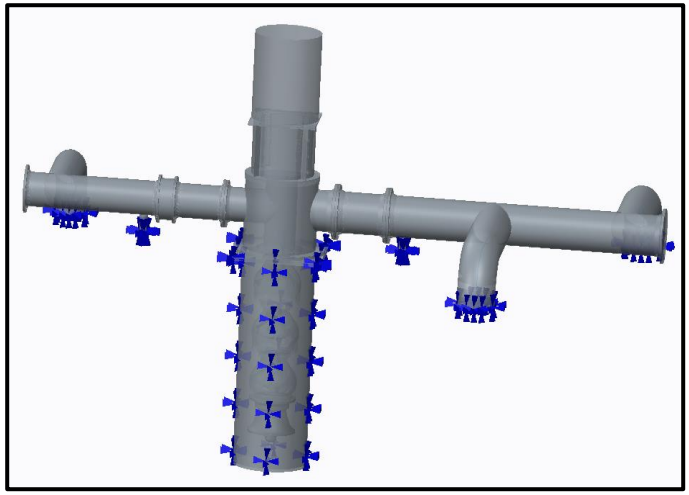


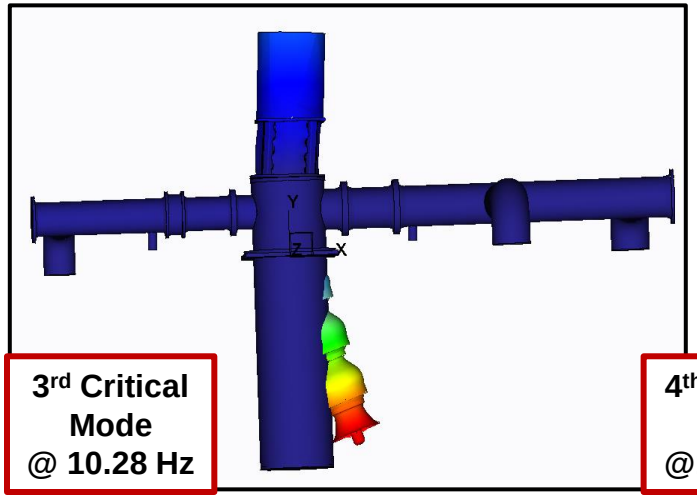


3rd Critical Mode @ 10.24 Hz

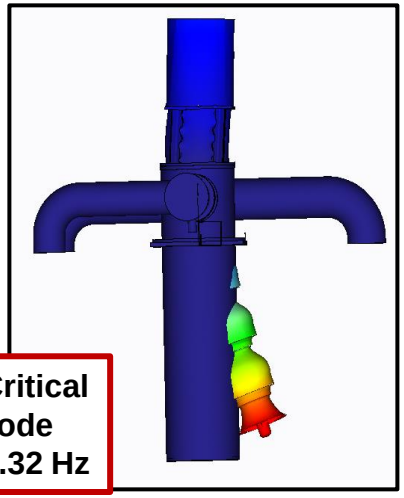


4th Critical Mode @11.29 Hz





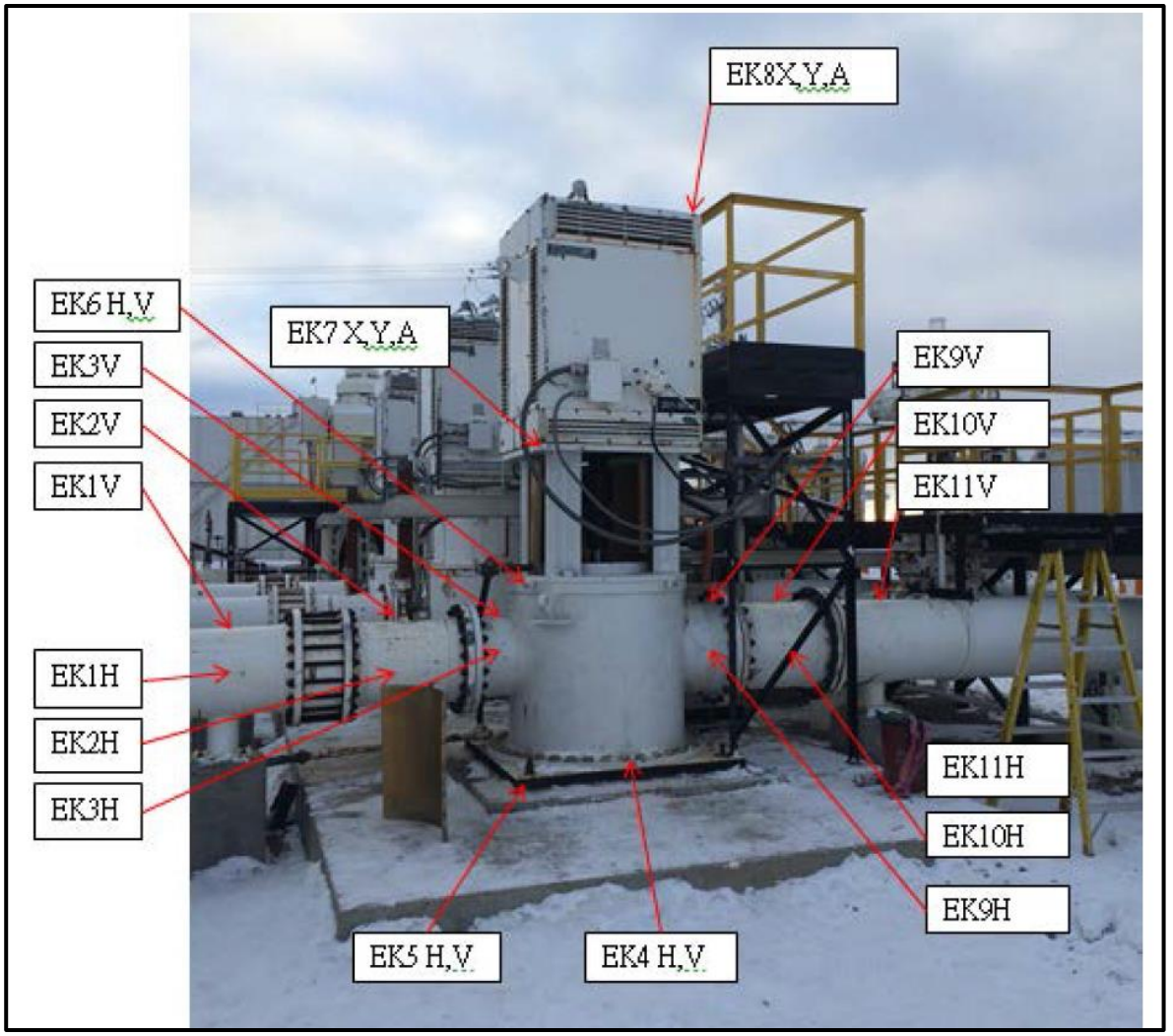
3rd Critical Mode @ 10.28 Hz



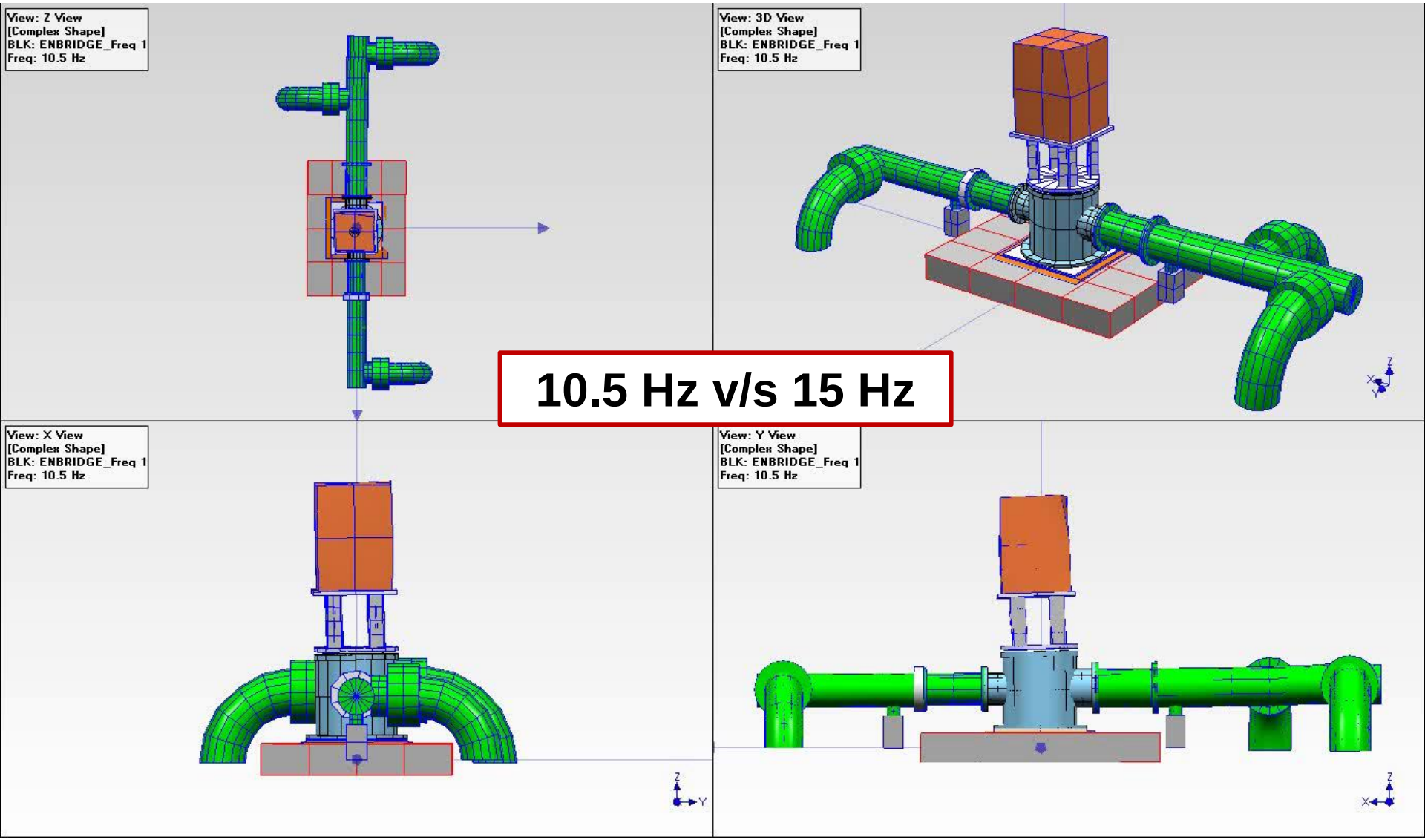
4th Critical Mode @11.32 Hz

Implementation of New Design at Field

Based on freezing water theory and study of FE analysis, design of New Motor Support installed on one out of three pumps at pump user site.



Field Test with Modified Design



Pump User's Comments after Modification

- I can absolutely endorse the fact that the newly retrofitted pump ran in both cold and warm ambient temperatures without any problems related to previous issues.
- To further that, the non-retrofitted pumps continued to respond the same way they always did. That being: they continued to need the hydraulic jacks for vibration mitigation during the colder ambient temperatures.
- I was there in person after the retrofit and saw for myself.

- Bryce Dreger(Enbridge Pipelines Inc.)

Lessons Learned

- This case study demonstrates the effective use of first-principle reasoning, verification by FE analysis, and validation by field testing to solve vibration problems in a complex and variable system.
- The case demonstrates inter-relationships of equipment and installation in a seasonally changing environment. And, the case presents an innovated design modification which retrofits into existing equipment to solve vibration problems.

Questions ?