

Investigation of Engine Vibration for Natural Gas Gathering and Transmission

Francisco J. Gonzalez
Sr. Director of Mechanical Reliability

Troy Feese, P.E.
Sr. Project Engineer
Engineering Dynamics Incorporated
San Antonio, Texas

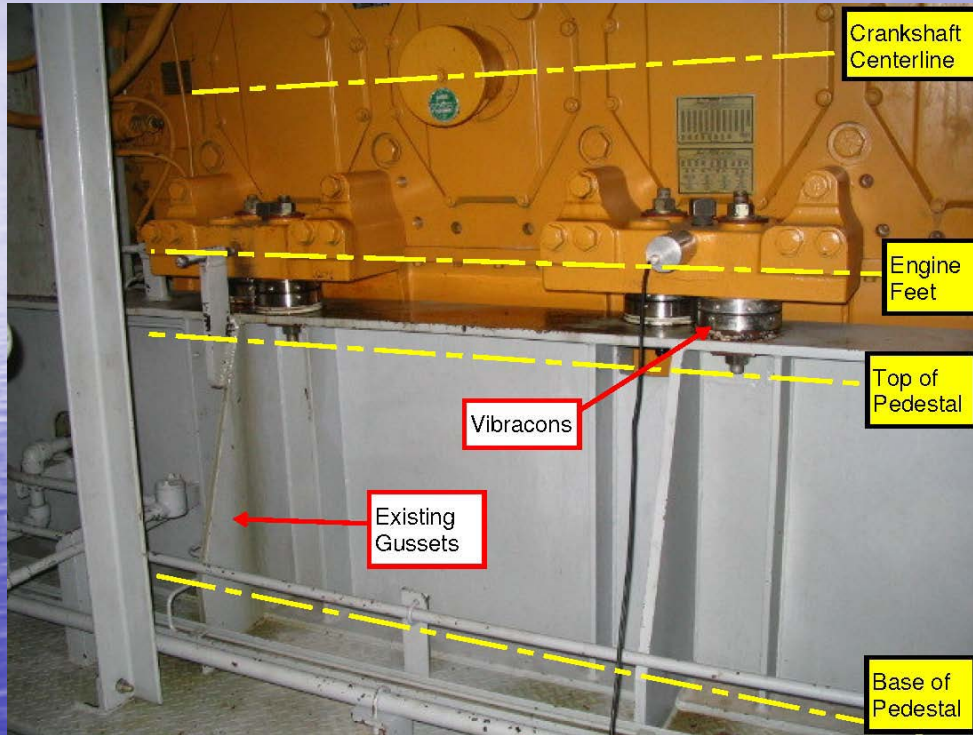
Background

- Compression of natural gas at gathering and transmission stations is commonly performed by engine driven reciprocating compressor systems.
- In the design stage, API 618 Design Approach 3 acoustical and mechanical study will typically be performed. However, packagers may overlook the engine skid mounting.
- When this equipment is skid-mounted, high frame vibration can occur if there is a mechanical natural frequency near the operating speed range.

16-Cylinder Natural Gas Engine Mounted on **Foundation** at Another Location



Compare to 12-Cylinder Natural Gas Engine Mounted on Skid



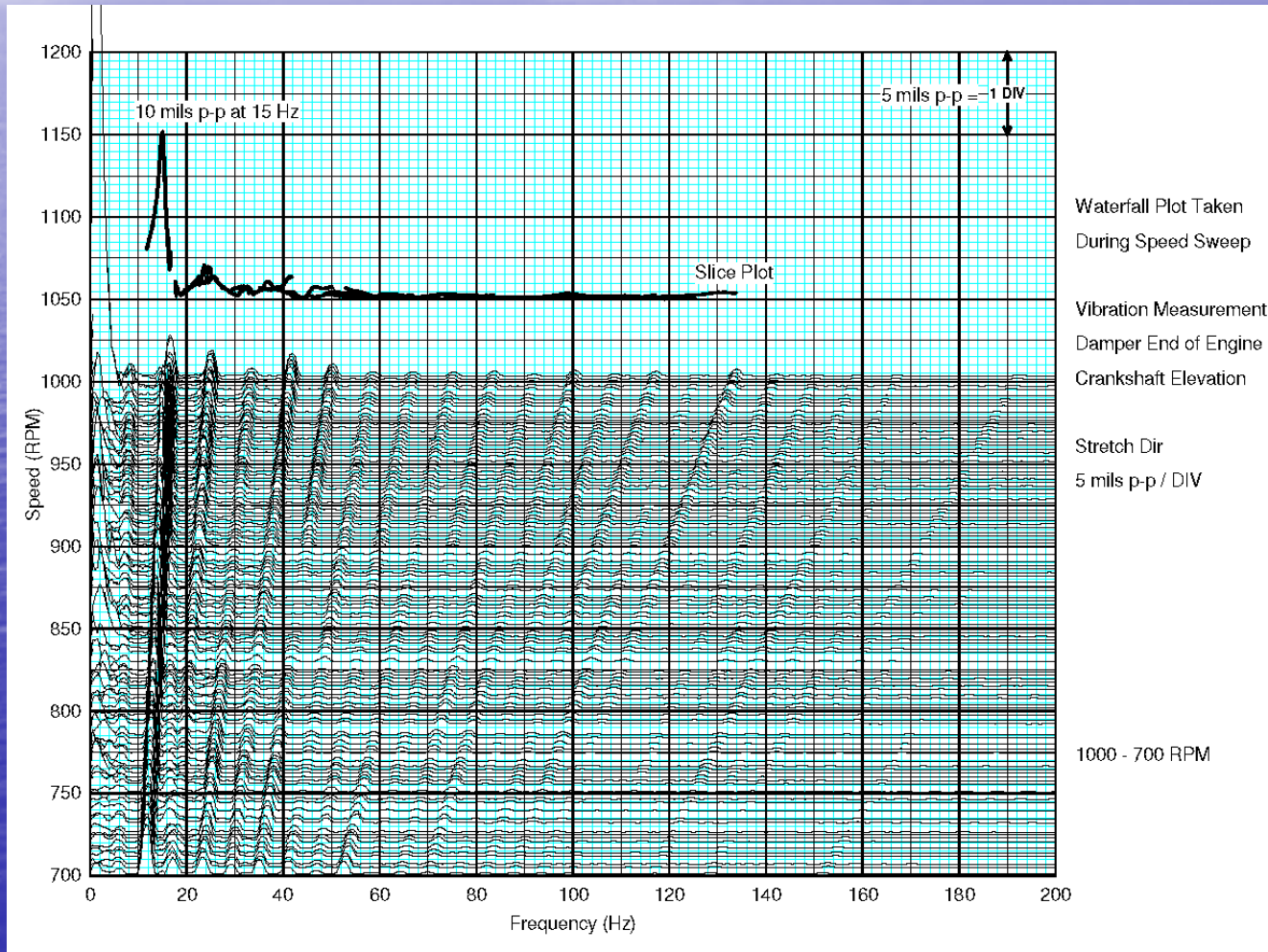
Equipment for Case History

- 12 Cylinder, 4 Cycle, Natural Gas Engine
- Rated for 3,550 HP
- Operating Speed of 700 – 1000 RPM
- 4 Cylinder Reciprocating Compressor
- Single-Stage, Double-Acting
- Natural Gas Service

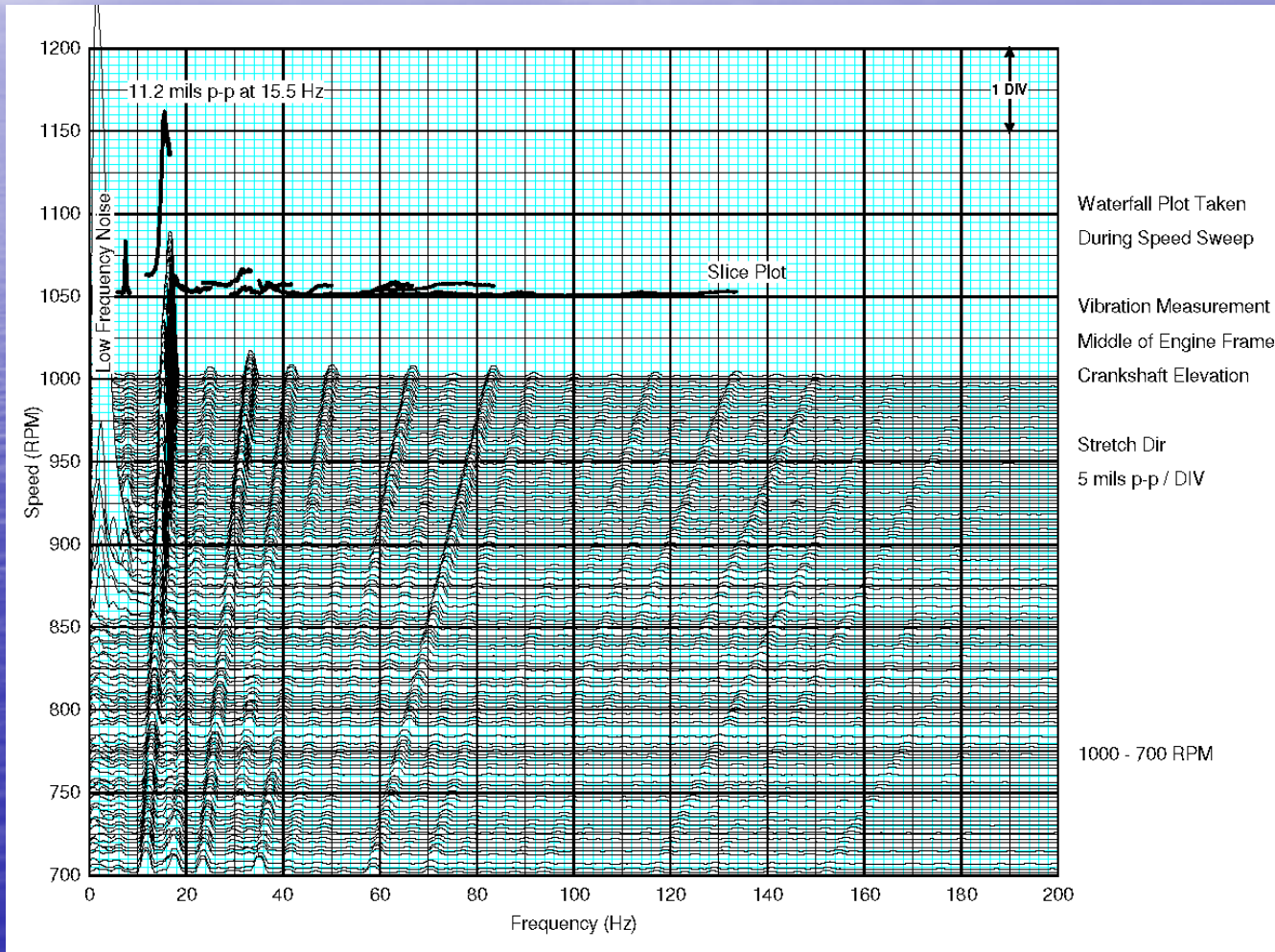
Engine – Compressor System



Vibration Measurement on Damper End of Engine



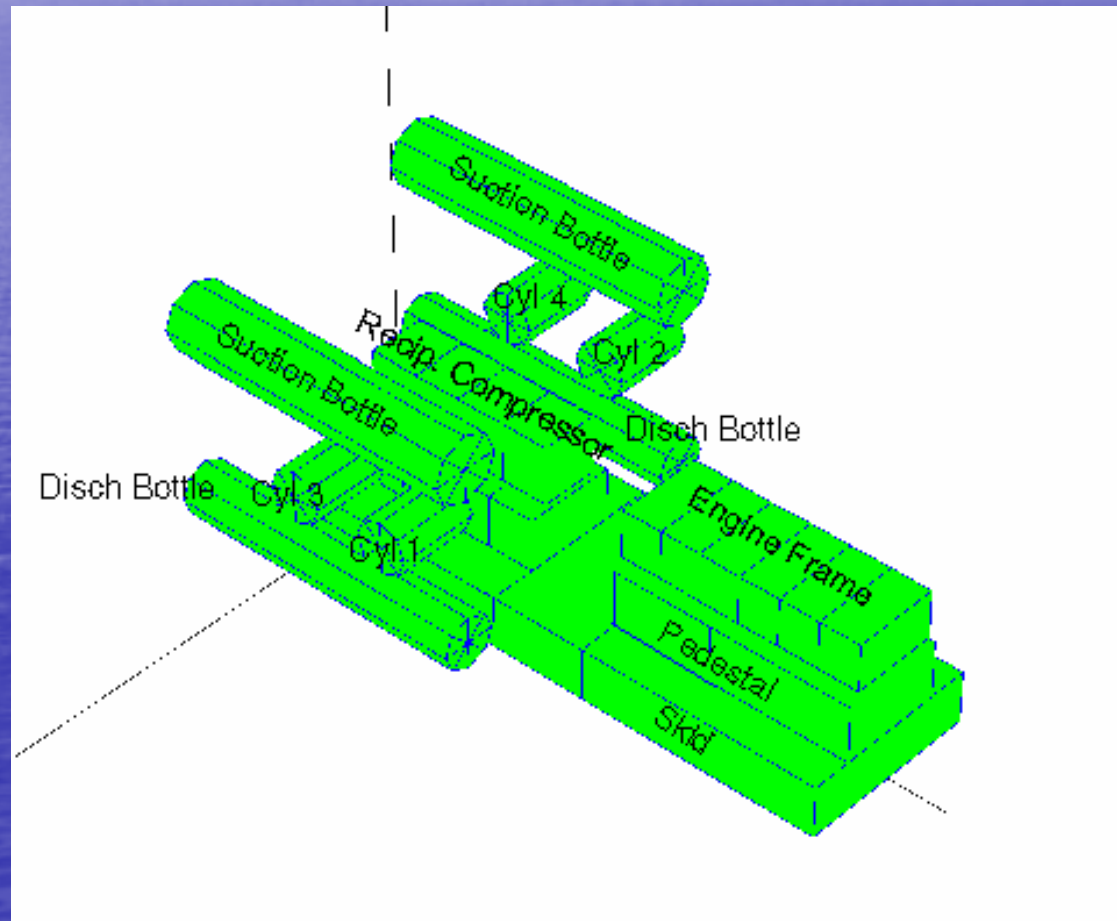
Vibration Measurement at Middle of Engine Frame



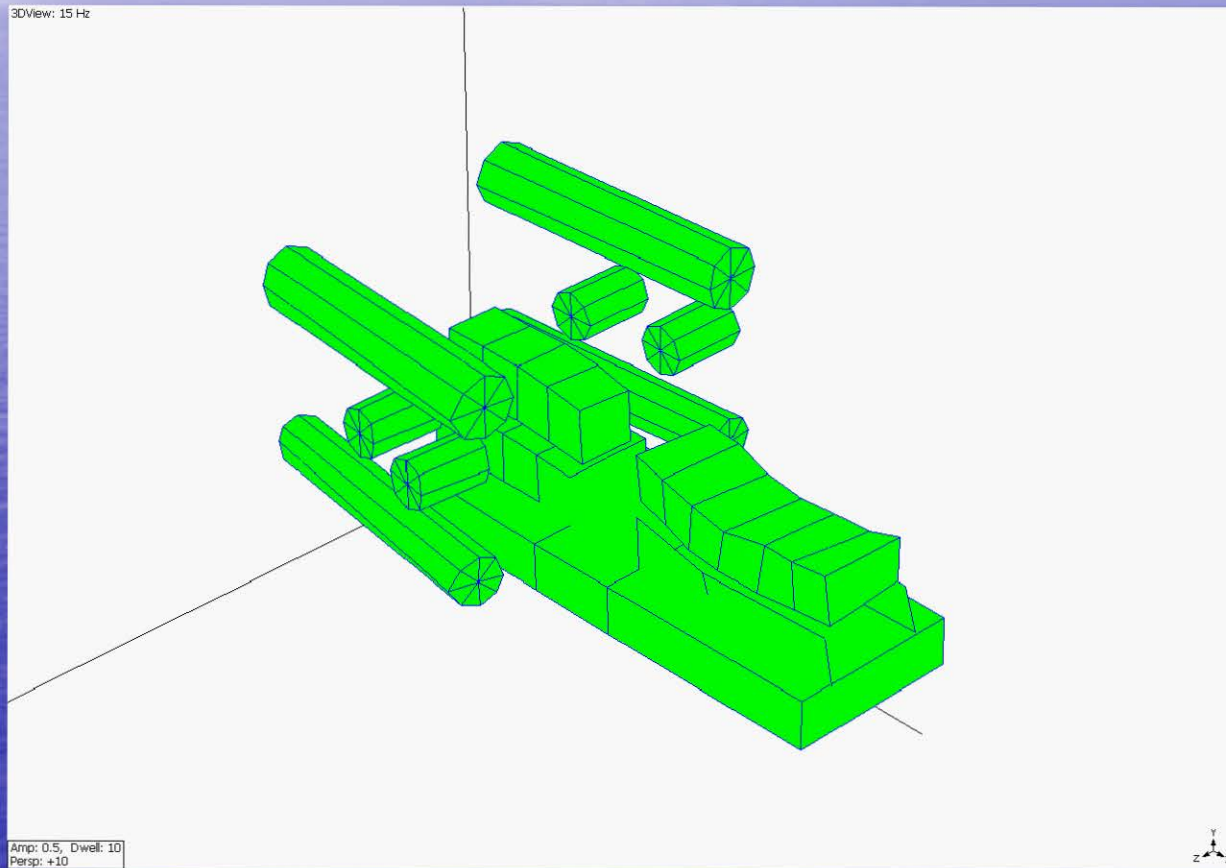
Summary

- At operating speeds of 900 – 930 RPM, the engine vibration levels exceeded manufacture's allowable of 5 mils p-p.
- High vibration may have contributed to #8 main bearing failure.
- Structural natural frequency found involving engine mounted on skid.

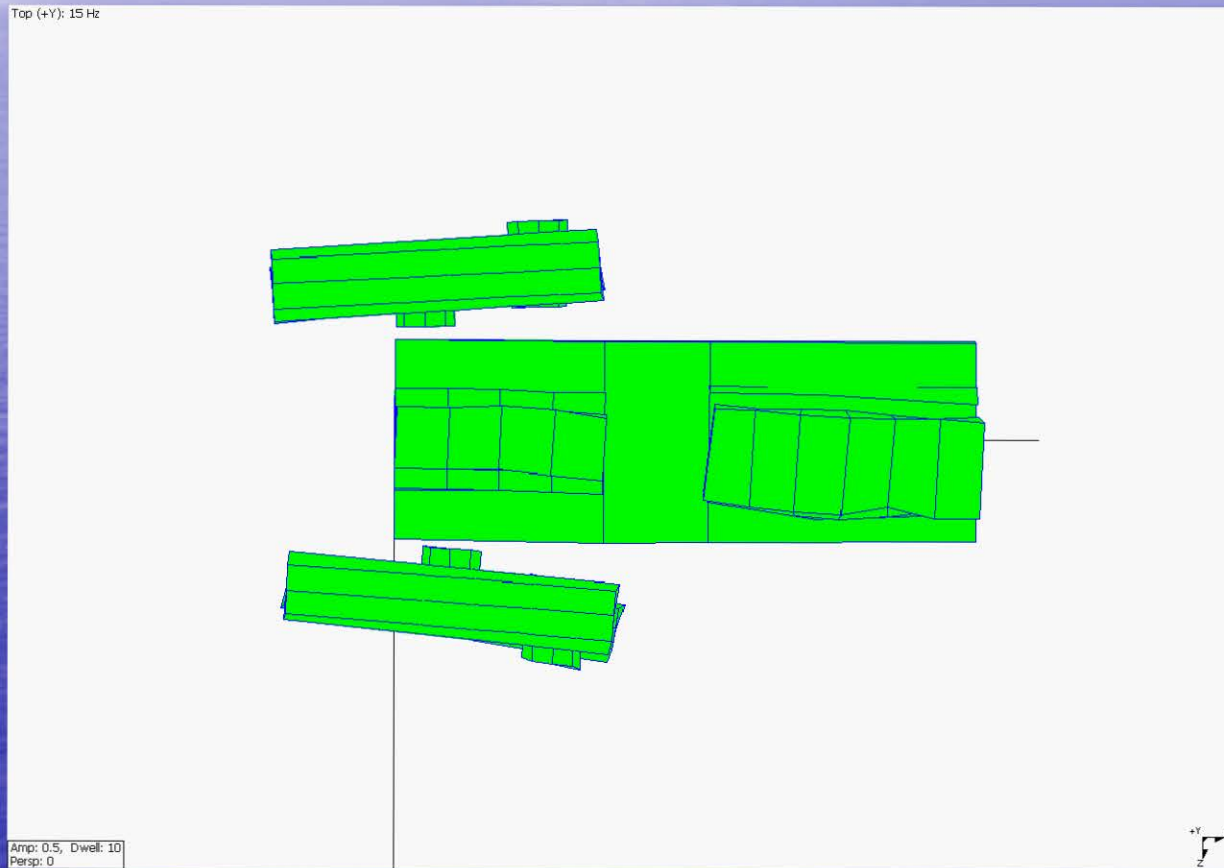
Model for Operating Deflection Shape (ODS) Measurement



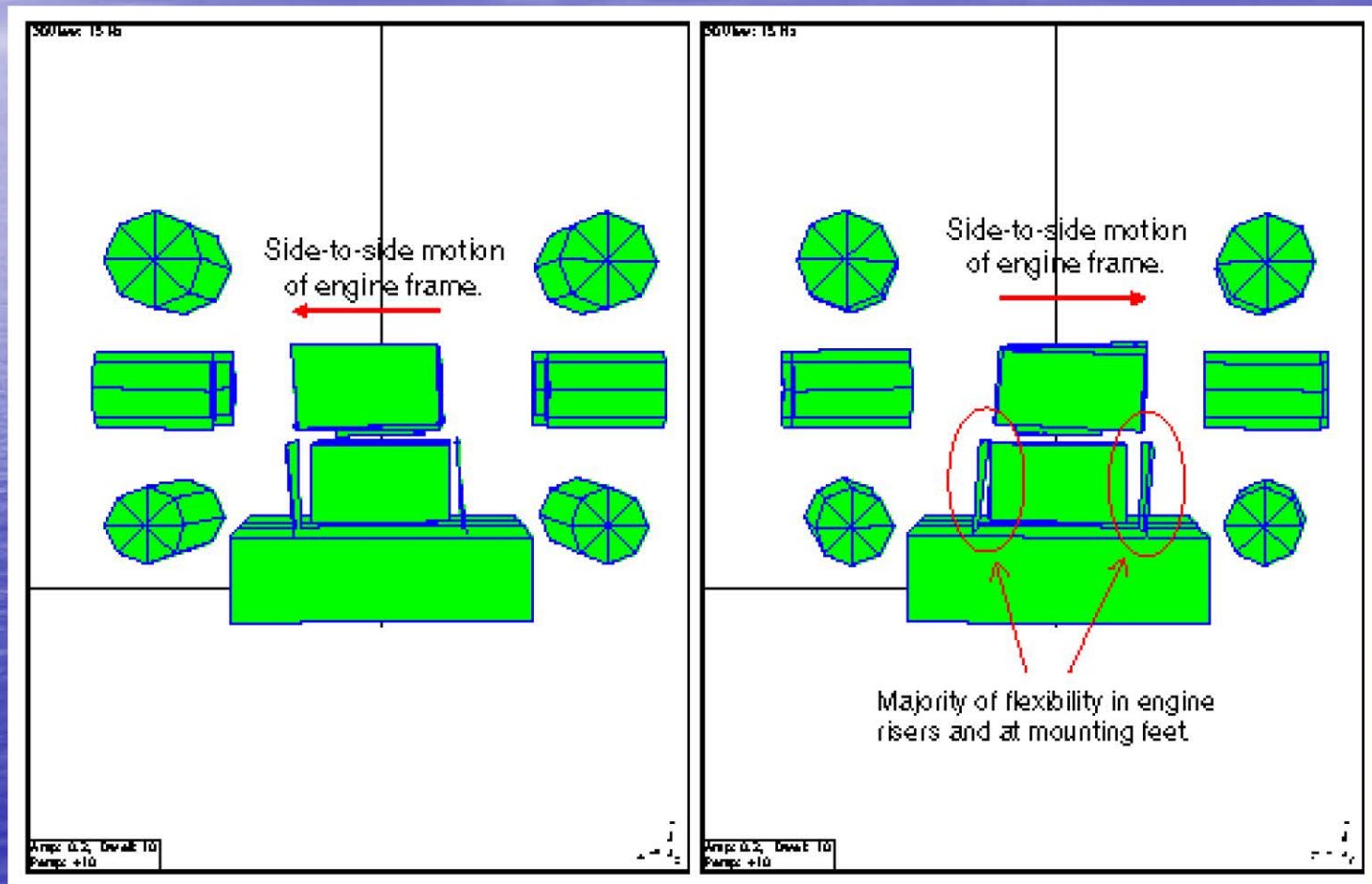
ODS – Iso View



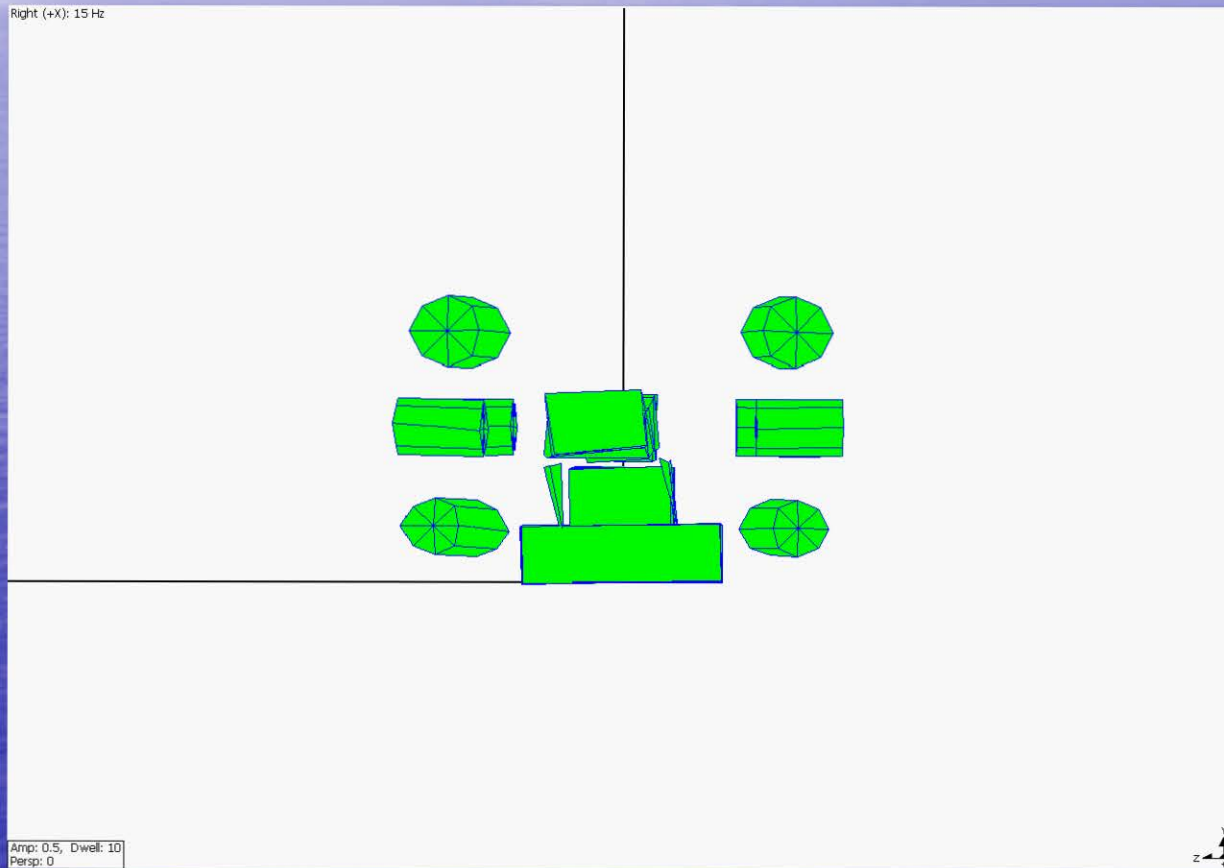
ODS – Top View



ODS – End View



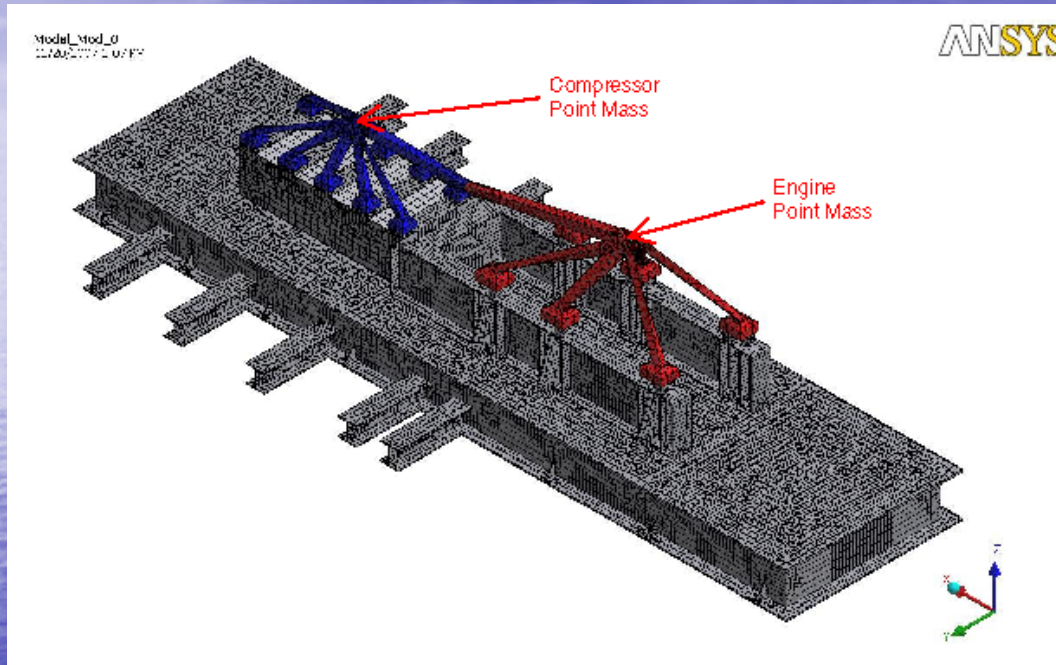
ODS – End View



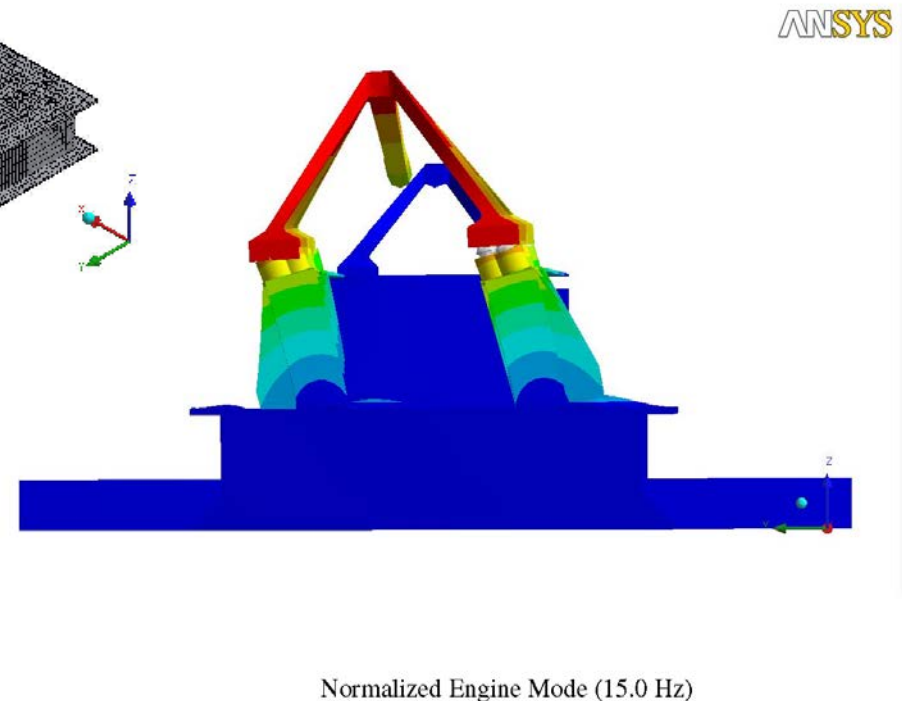
Recommendations

- Increase natural frequency of engine / pedestal above running speed while still maintaining a separation margin from $2\times$ running speed.
- This requires stiffening the pedestal with gussets or re-design of the entire skid.
- To ensure engine is securely mounted on Vibracons, anchor bolt tension should be checked.
- Avoid using additional washers with Vibracons.

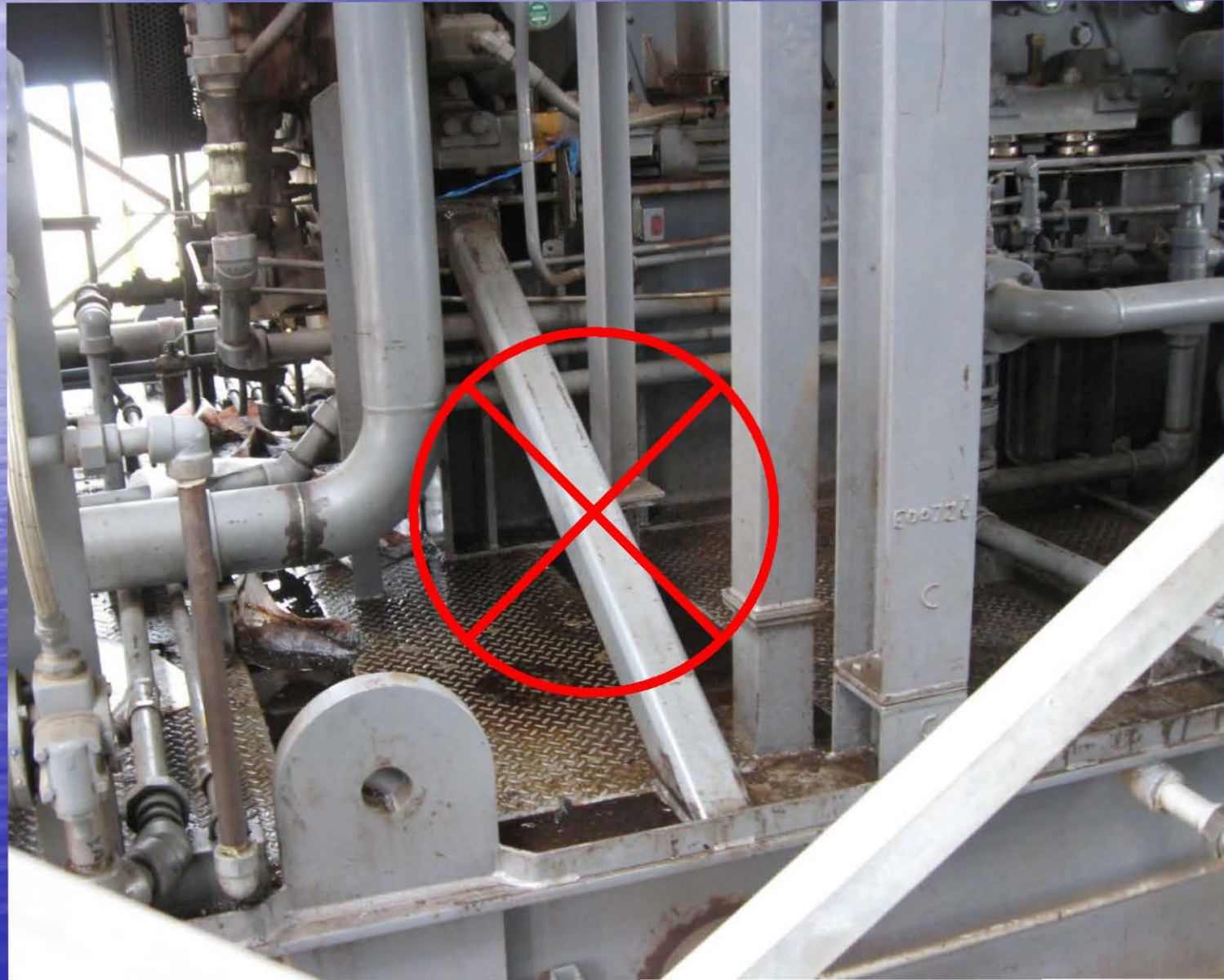
Finite Element Analysis (FEA)



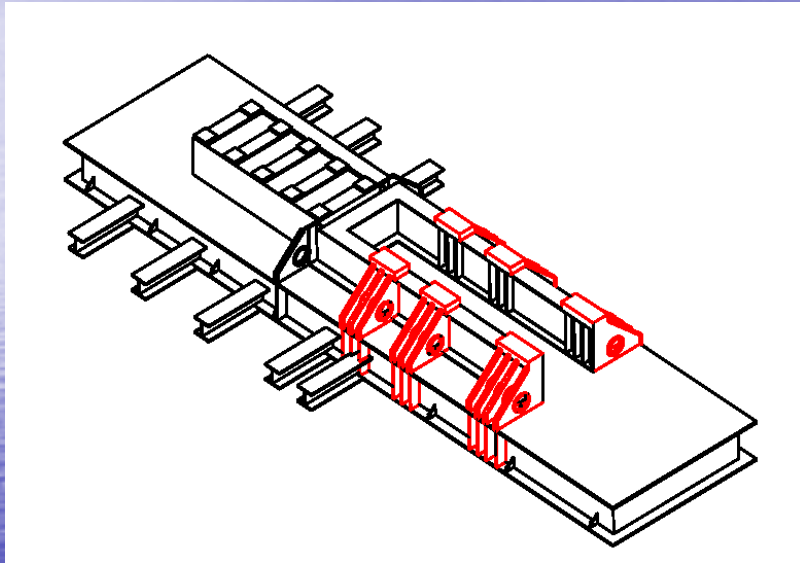
Normalize FEA
Model to Field
Measurements



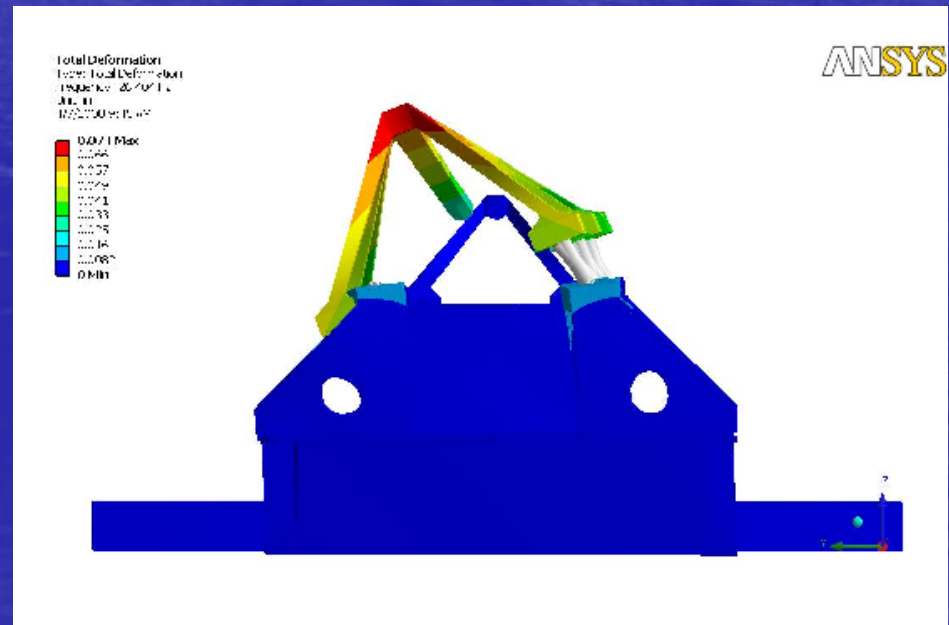
Example of Kick Brace With Insufficient Stiffness (Different Unit)



Proposed Modifications – Add Gussets to Skid Under Engine



FEA Predicts
26 Hz →



Engine Skid Modifications



After Modifications Performed

- Vibration readings on the engine are within manufacture specifications after modifications
- Perform routine vibration checks with compressor performance