– Case Study –
Uncommon, Very Effective Solution to PD Pump Pulsation & Vibration Problem

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Agenda

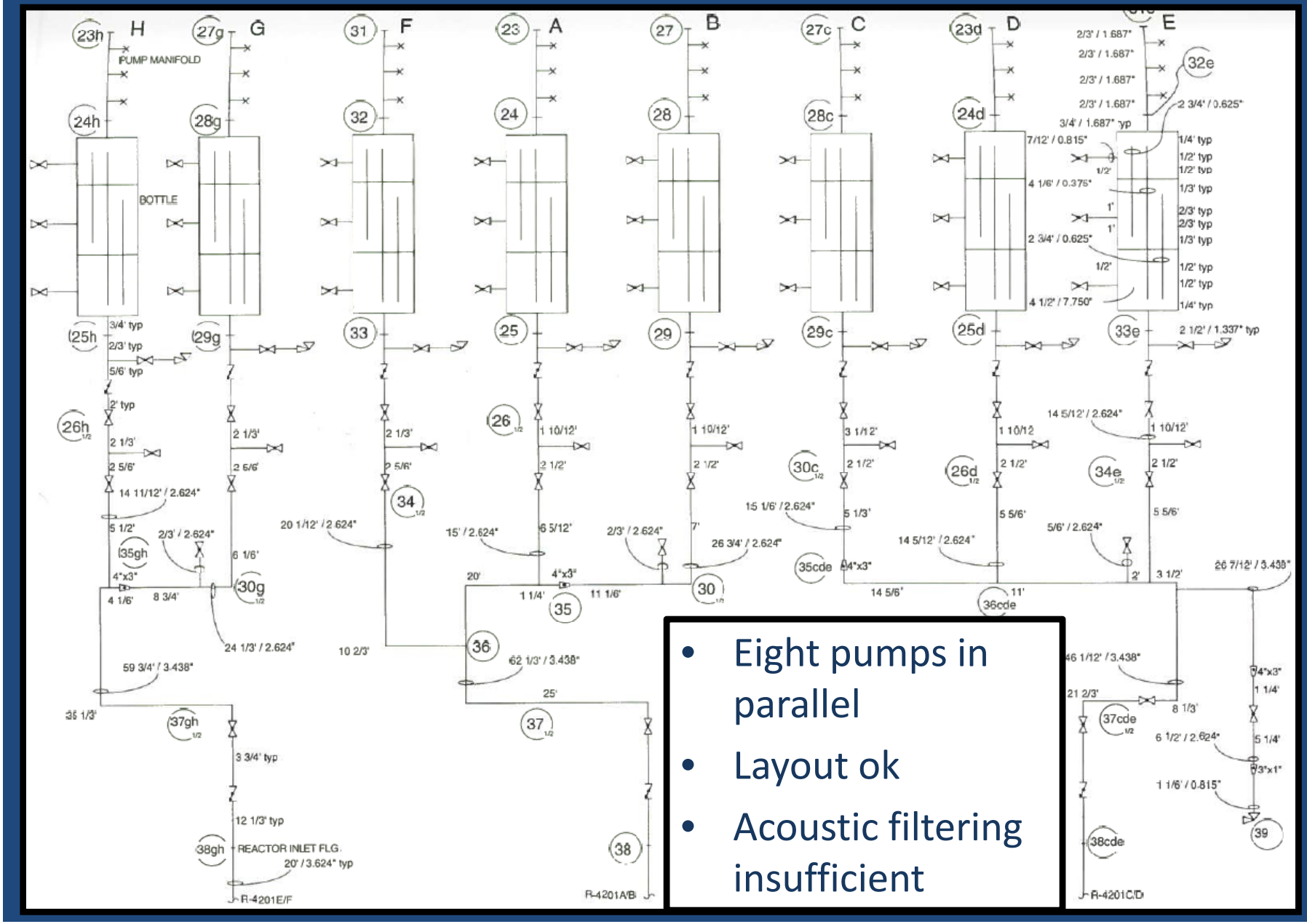
- Introduce System & Problem
- Steps taken to Solve Problem
- Summary & Lessons Learned

Pump Description Details

Pumps Details
8 parallel pumps (plunger)
3 plungers per pump
2.25” bore (5.7 cm)
5” stroke (12.7 cm)
303 rpm
75 gpm (17 m^3/hr)

Pump Operating Conditions
160 psig (11 barg)
80 F (26.7 C)
3000 psig (207 barg)
140 F (60 C)

Original Pumps Discharge Piping System Layout

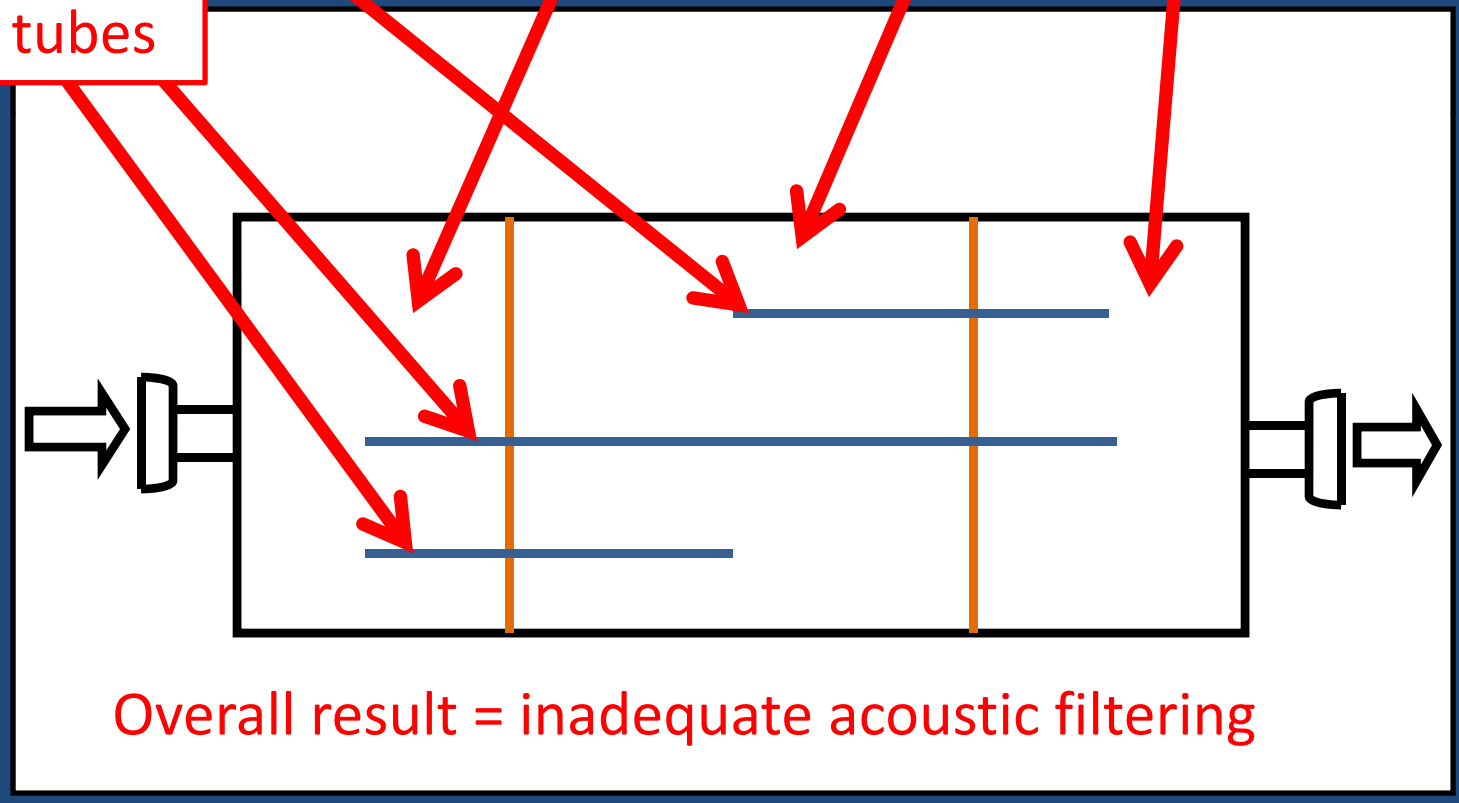


- Eight pumps in parallel
- Layout ok
- Acoustic filtering insufficient

Existing Pumps Outlet Vessel Internals

Desirable to reduce pressure losses of choke tubes

Vessel volumes insufficient (7.75” ID)



Overall result = inadequate acoustic filtering

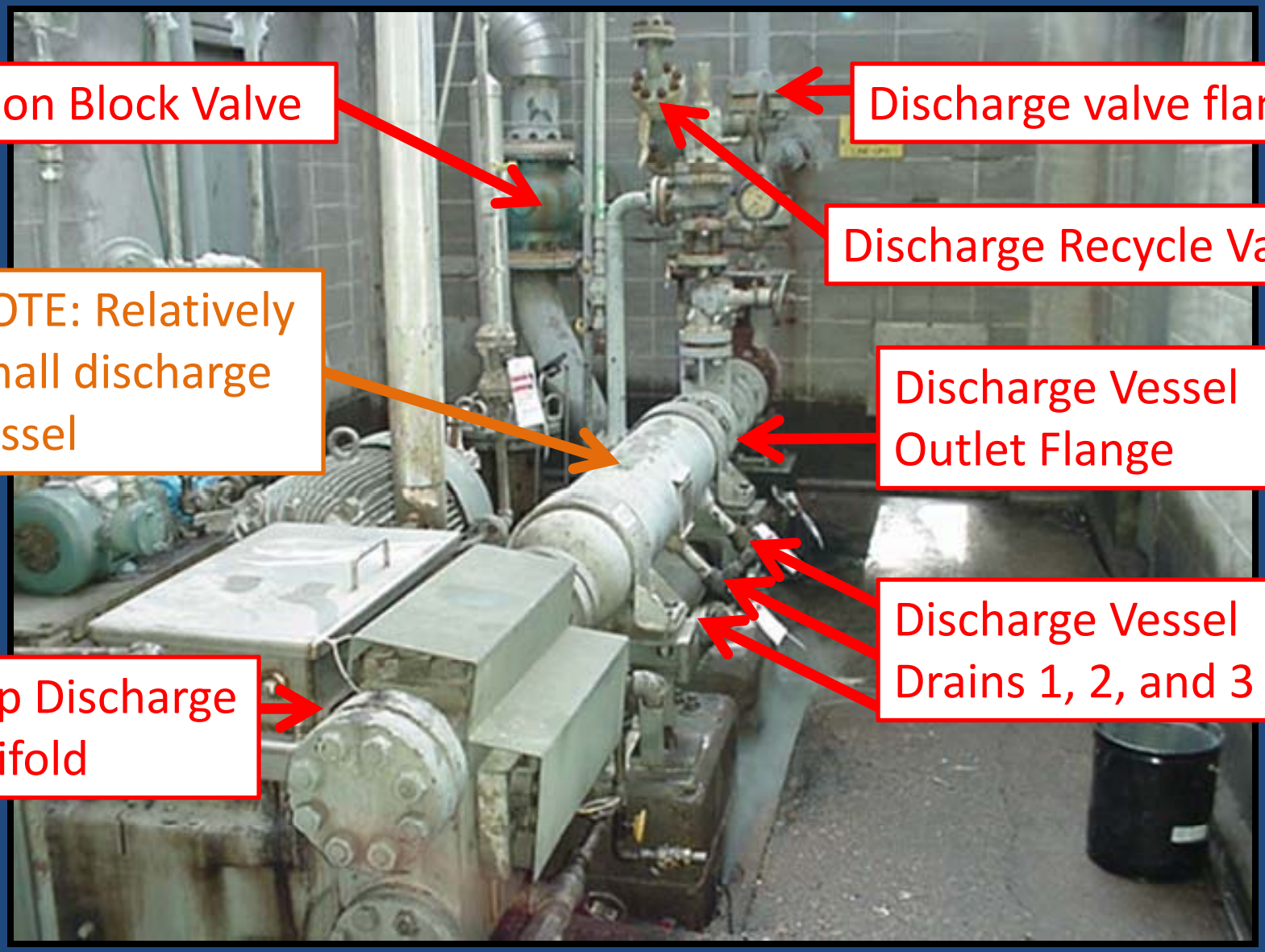
Problems

- Suction and discharge piping vibrations
- Failures
  - Drain connections
  - Gussets on discharge vessel
- General suction and discharge piping vibrations
- Issues above raised safety & reliability concerns

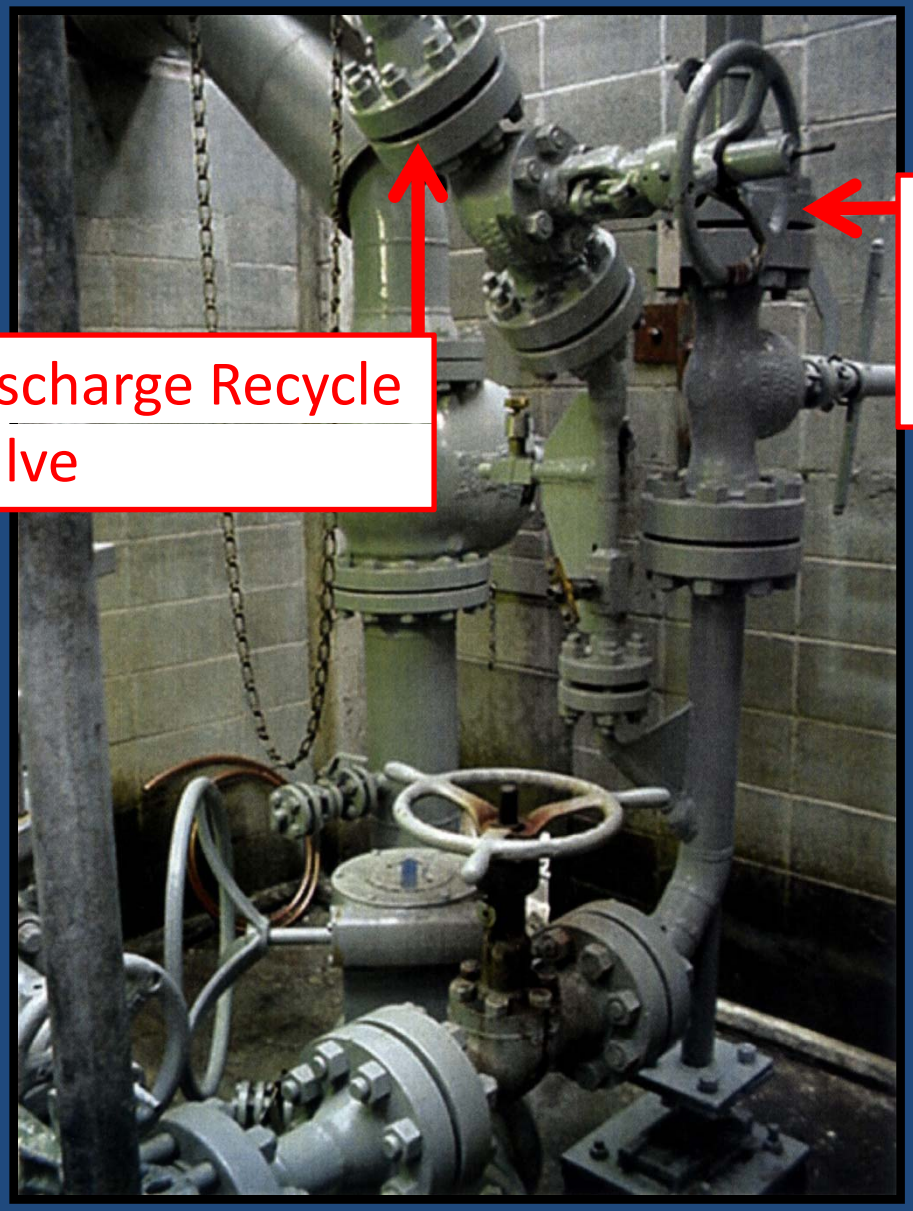
Steps Taken to Solve Problem

- Field vibration & pulsation data acquired
- Pulsation analysis performed
- More effective acoustic filter bottle recommended

Pump Piping System – Vibration & Pulsation Test Points

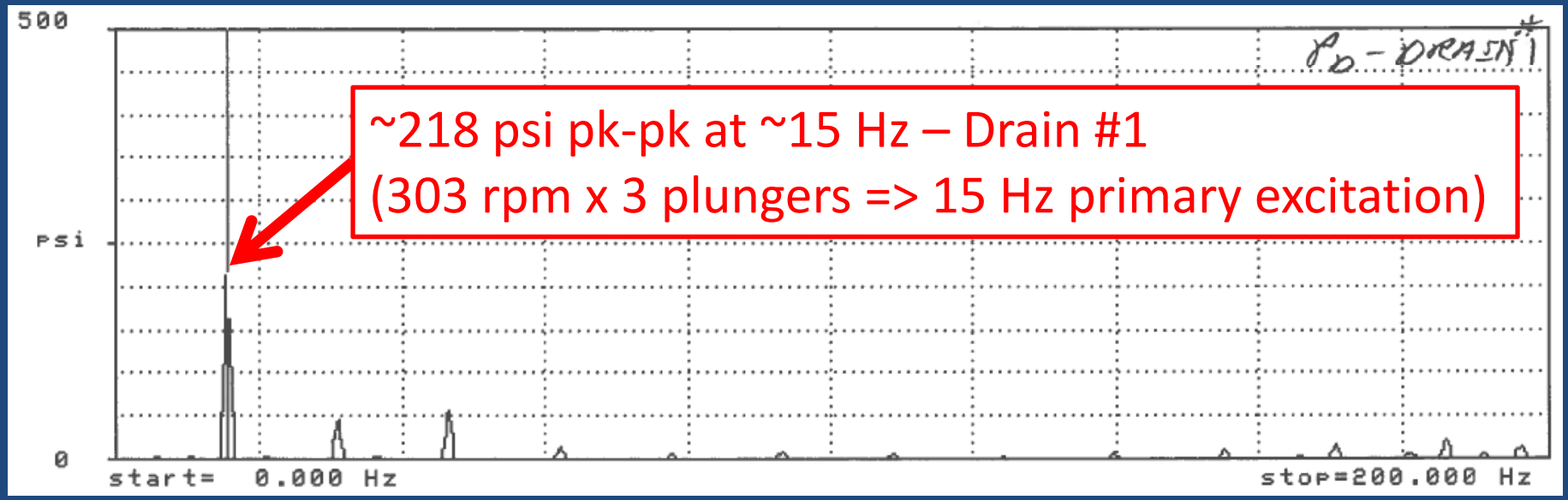


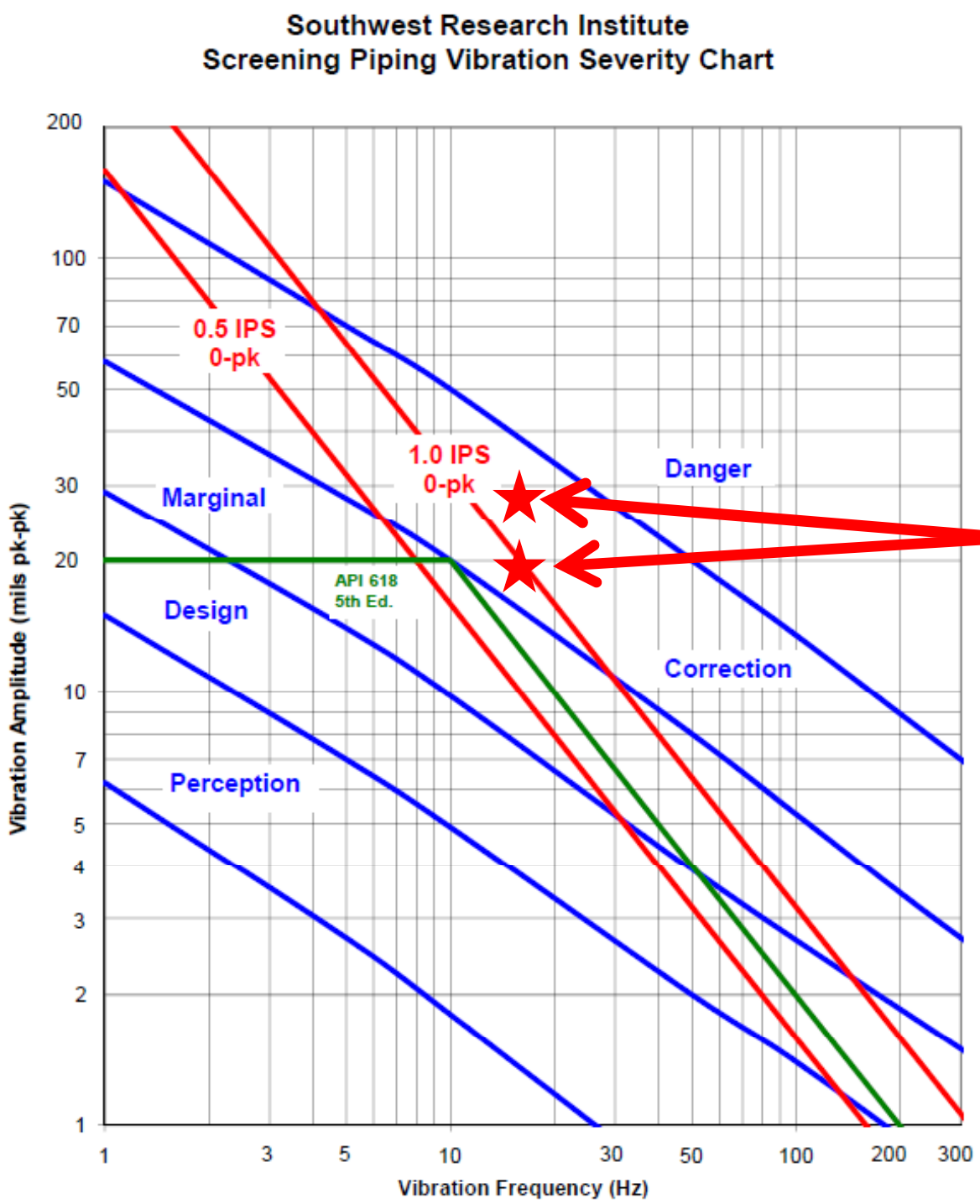
Pump Piping System – Vibration Test Points



Field Vibration and Pulsation Data

- Some vibrations excessive (magnetic dynamic velocity probes)
  - Discharge valve flange ~27 mils p-p at ~15 Hz
  - Discharge recycle valve ~19 mils p-p at ~15 Hz
- High pulsations (PCB dynamic pressure probes used)
  - Drain (see below)
  - Vessel outlet piping ~60 psi pk-pk at ~15 Hz



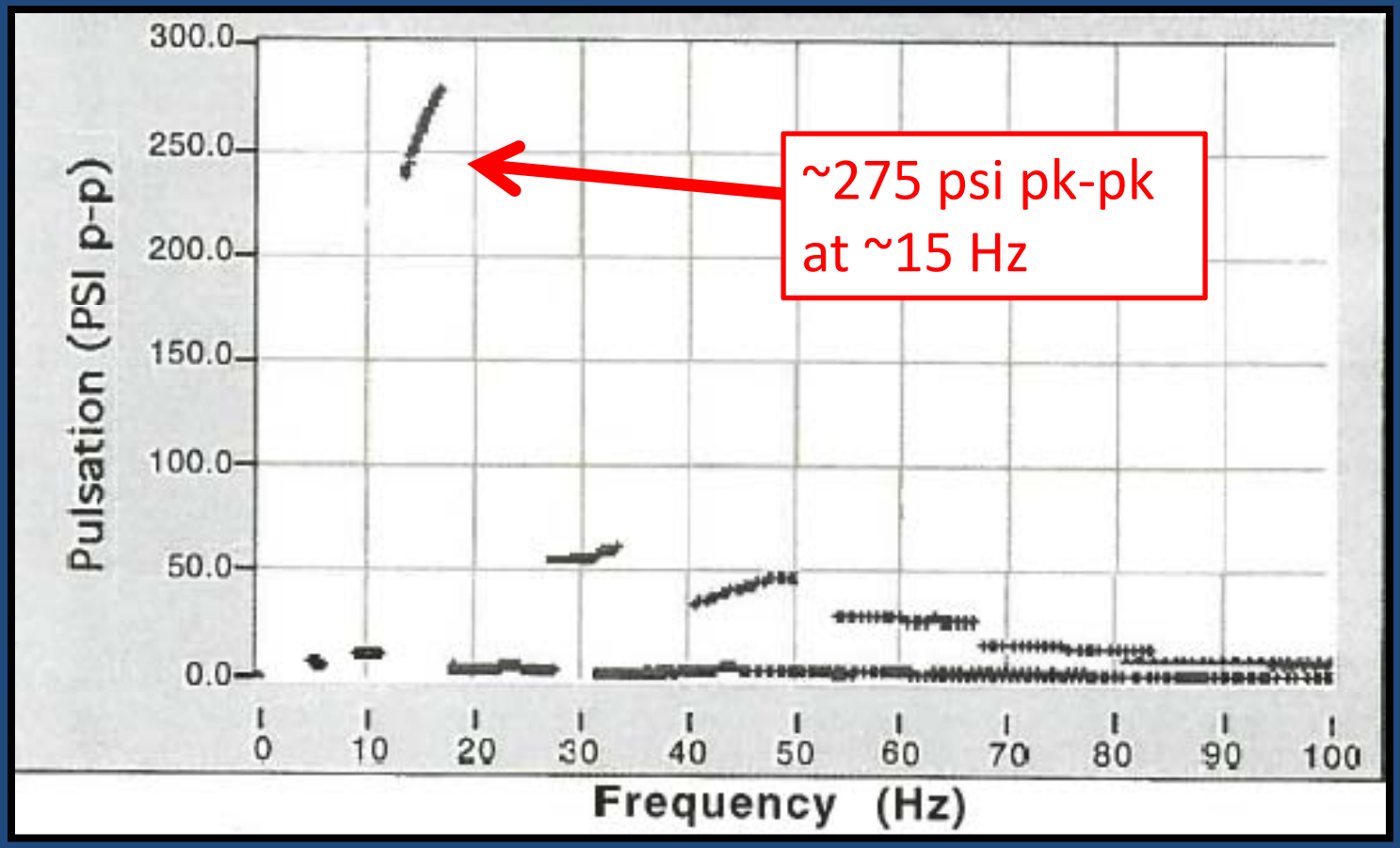


Field Vibrations on Vibration Guideline Chart

Field measured vibrations in "Correction" region

Pulsation Analysis/Modeling

- High amplitude pulsations predicted
  - Pump manifold (see below)
  - Vessel outlet piping ~30-40 psi pk-pk at ~15 Hz

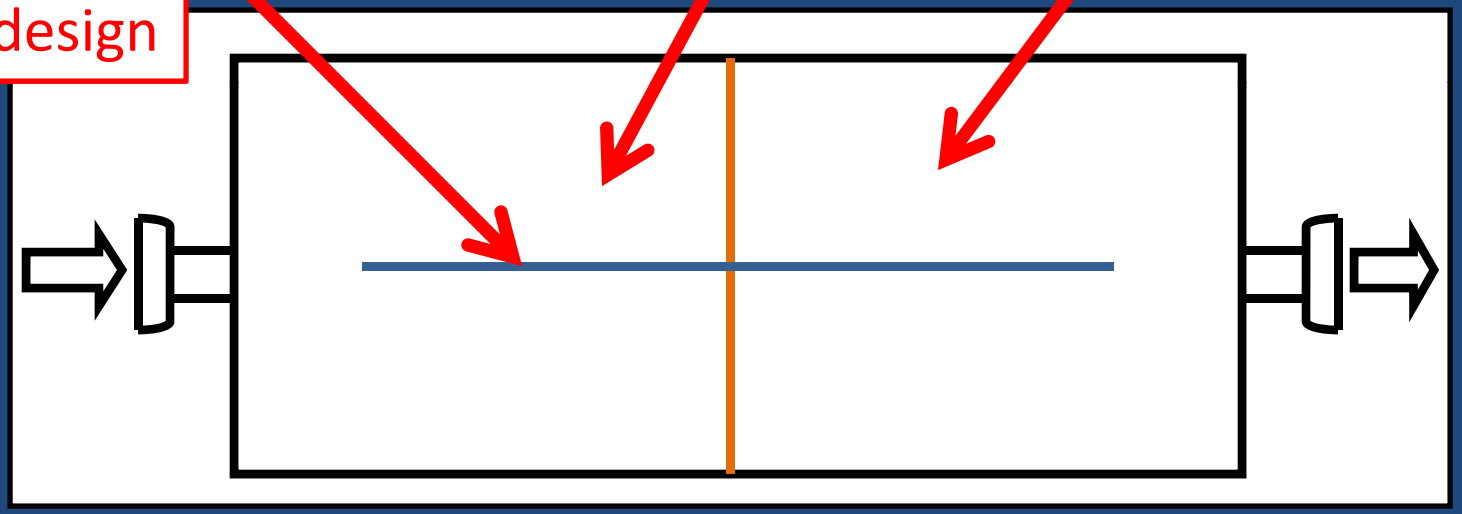


Solution – Acoustic Filter Recommended

Choke tube sized with less pressure losses than originally installed design

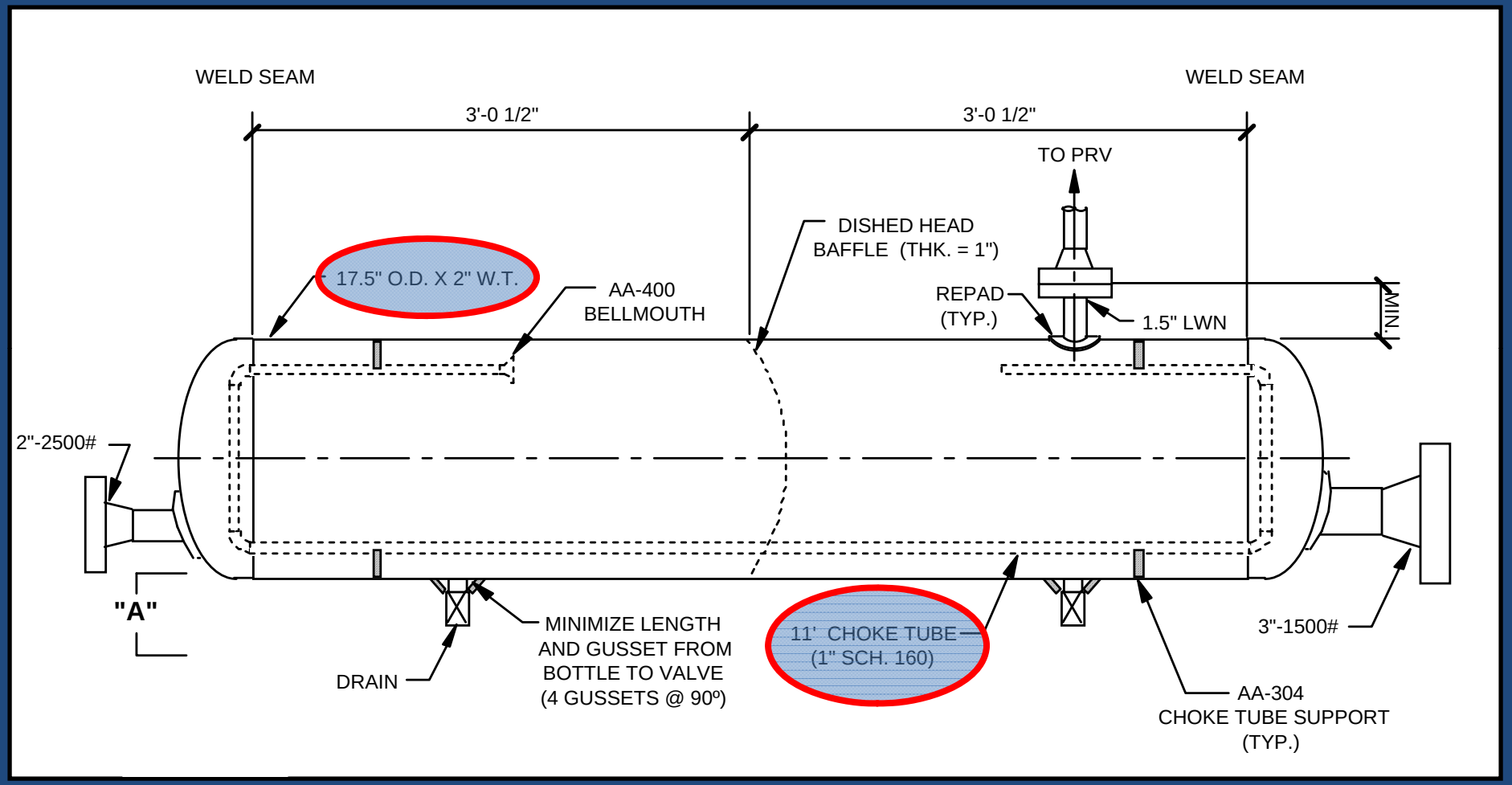
Original system pressure drop = 100 psi
Recommended system pressure drop = 83 psi

Vessel volumes sufficient



- Overall result = Excellent acoustic filtering (filter response placed well below 1x, which is 3 x running speed for triplex pump)
- Owner satisfied with reduction of system vibration --> installed recommended filter vessel on all 8 units

Solution – Acoustic Filter Details



- Actual installed bottle: Approximately same volume as above, but shorter & larger diameter (& ~2-feet longer choke)
- Longer choke (more elbows) --> pressure drop ≈ original vessel

Equation – Acoustic Filter

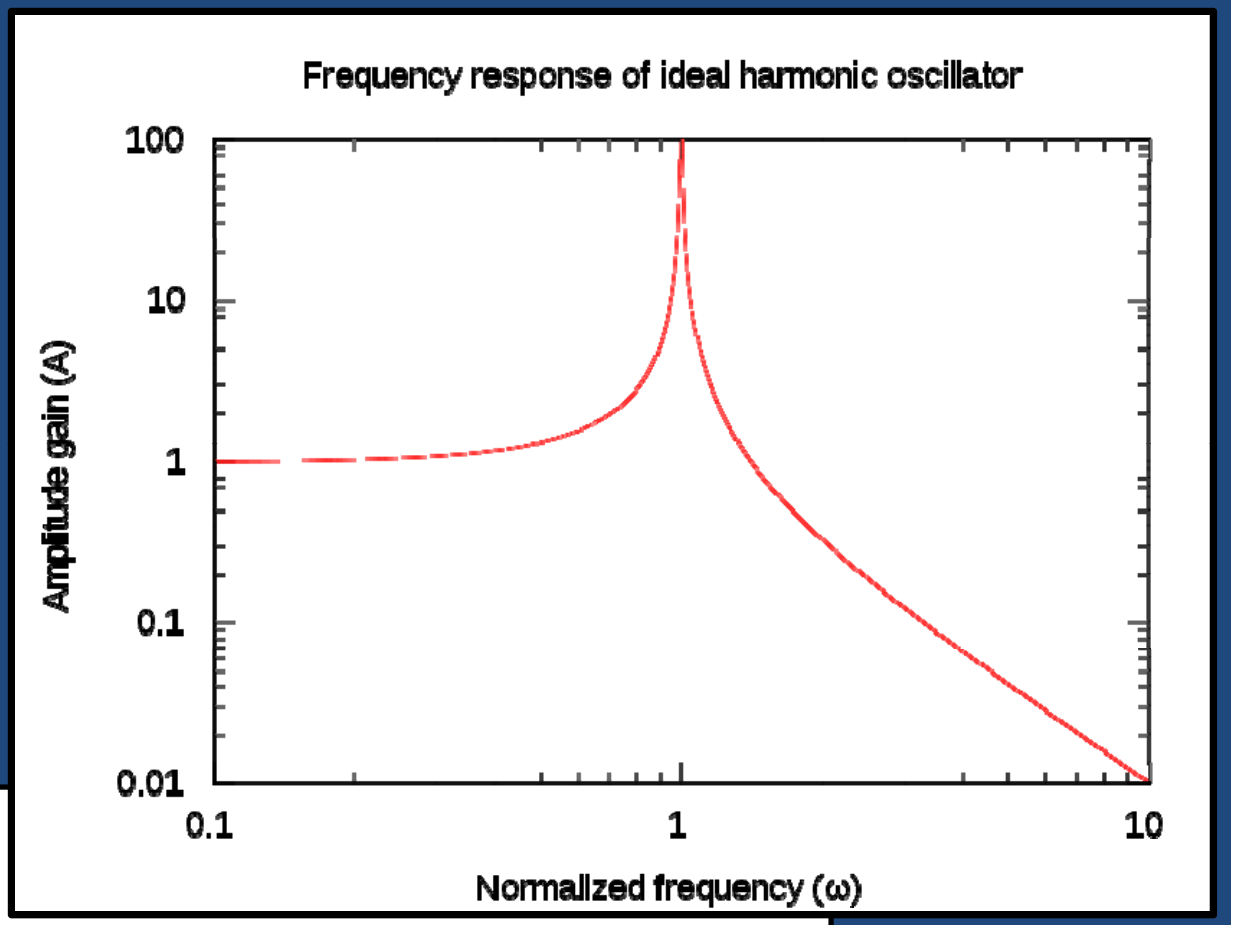
- Info needed for calculating Helmholtz (acoustic filter) frequency
  - Speed of sound in liquid
  - Geometry dimensions

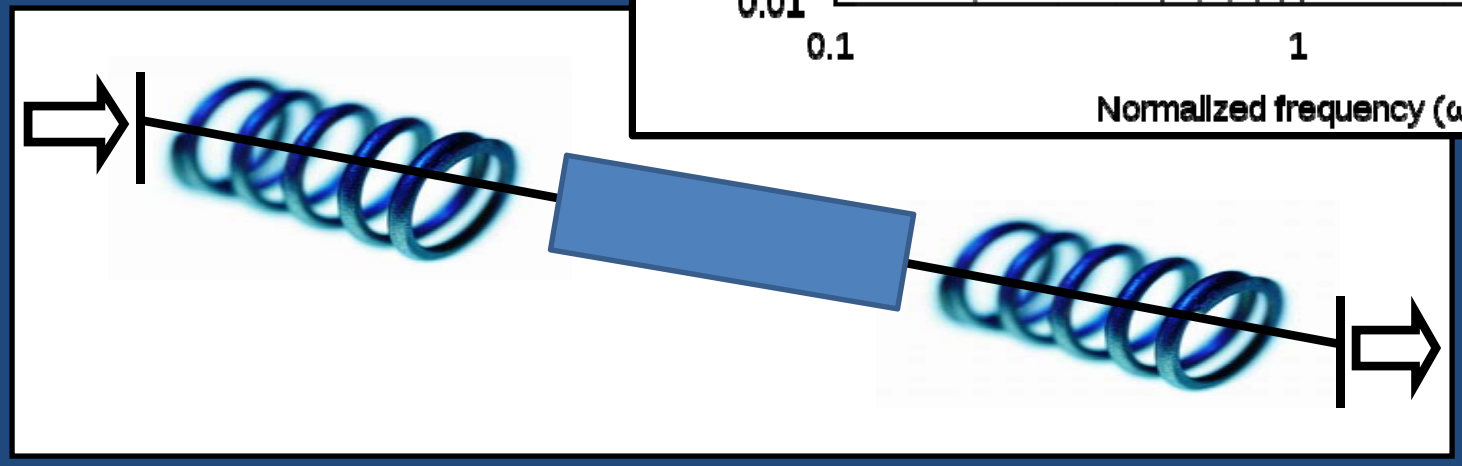
$$f_H = \frac{c}{2\pi}\left(\frac{\mu}{V_1}+\frac{\mu}{V_2}\right)^{\frac{1}{2}} \qquad \mu = \frac{A}{L}$$

f_H = Helmholtz frequency (Hz)
A = Cross-sectional area of choke (ft^2)
L = Acoustic length of choke (ft)
c = Velocity of sound (ft/sec)
V_1 = Volume of cylinder bottle or chamber (ft^3)
V_2 = Volume of filter bottle or chamber (ft^3)

General Concept of an Acoustic Filter

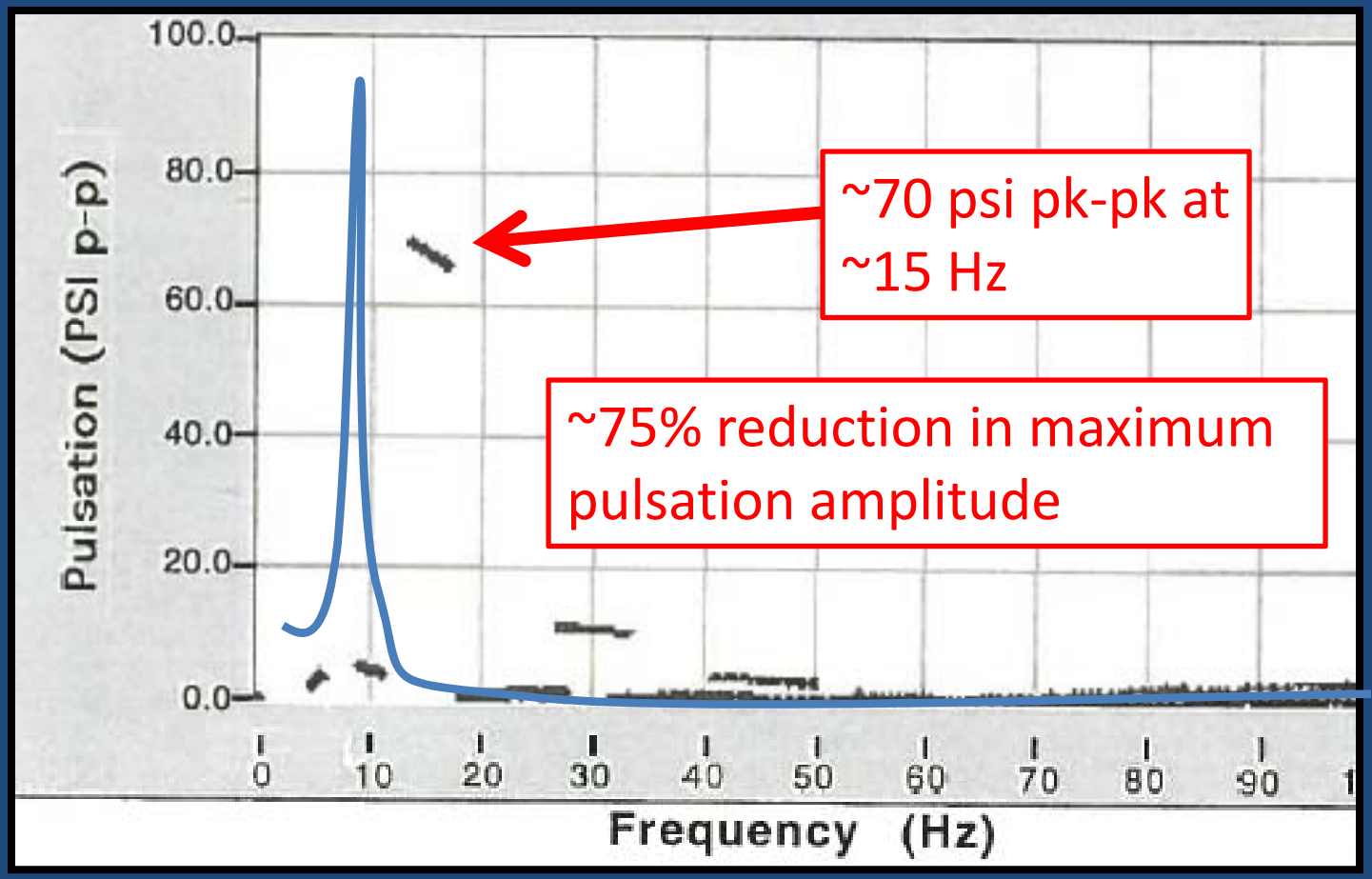
- Analogous to low-pass electrical filter or **mechanical system**
  - Volume = Spring
  - Choke tube = Mass





Pulsation Analysis/Modeling – Modified System

- Lower pulsations predicted
  - Pump manifold (see below)
  - Vessel outlet piping ~5-10 psi pk-pk at ~15 Hz



Summary and Lessons Learned

- Introduce System & Problem
  - High piping vibrations
  - Piping and gussets failures
- Steps taken to Solve Problem
  - Field study – vibration and field data
  - Pulsation analysis
- Summary & Lessons Learned
  - Well designed acoustic filter significantly reduces system pulsations

Questions/Comments?

Please ask. If you have a question, someone else in the room probably has a question also.