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

Eugene “Buddy” Broerman
Senior Research Engineer
Southwest Research Institute
Agenda

• Introduce System & Problem

• Steps taken to Solve Problem

• Summary & Lessons Learned
## Pump Description Details

### Pumps Details

<table>
<thead>
<tr>
<th>Description</th>
<th>Details</th>
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<tr>
<td>8 parallel pumps (plunger)</td>
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<tr>
<td>3 plungers per pump</td>
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<tr>
<td>2.25” bore (5.7 cm)</td>
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<tr>
<td>5” stroke (12.7 cm)</td>
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<tr>
<td>303 rpm</td>
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<td>75 gpm (17 m³/hr)</td>
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### Pump Operating Conditions

<table>
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<th>Details</th>
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<td>160 psig (11 barg)</td>
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<tr>
<td>80 F (26.7 C)</td>
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<tr>
<td>3000 psig (207 barg)</td>
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<tr>
<td>140 F (60 C)</td>
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</table>
• 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

NOTE: Relatively small discharge vessel

Suction Block Valve

Discharge valve flange

Discharge Recycle Valve

Discharge Vessel Outlet Flange

Discharge Vessel Drains 1, 2, and 3

Pump Discharge Manifold
Pump Piping System – Vibration Test Points

Discharge Recycle Valve

Discharge valve flange
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

~218 psi pk-pk at ~15 Hz – Drain #1
(303 rpm x 3 plungers => 15 Hz primary excitation)
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

~275 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

\[
f_H = \frac{c}{2\pi} \left( \frac{\mu}{V_1} + \frac{\mu}{V_2} \right)^{1/2}
\]

\[
\mu = \frac{A}{L}
\]

- \( f_H \) = 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

~70 psi pk-pk at ~15 Hz

~75% reduction in maximum pulsation amplitude
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.