Improving Performance of Gas Lift Compressors in Liquids-Rich Gas Service

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Outline

• Financial Impact of Compressor Downtime

• Understanding Compression
  – Designed for Gas Sales from lean gas wells
  – Condensation issues with liquids-rich gas

• Impact of condensation to operations

• Methods to mitigate operating problems

• An Alternative: Prevention by design change
Financial Impact of 5% Downtime

• Gas Sales: 750 MCFPD
  – $3.00 MCF, 75% NRI: $3,420 per month

• Gas Lift of 750 MCFPD
  – Producing 250 BOPD, 500 BWPD, 250 MCFPD
  – $5.00 MCF, $50 Oil, $1 SWD, 75% NRI: $14,415
  – 4.6 times more impact to cash flow

• Rental Rate Refund for 5% Downtime
  – $6000 monthly rental fee x 5% = $300
Understanding Compression: The Phase Diagram
Phase Diagram for 100 F Ambient Gas Well Sales (Lean 0.65 Gravity)

- Temps kept above 120 F, no hydrocarbons condense
Phase Diagram for 30 F Ambient Gas Well Sales (Lean 0.65 Gravity)

- Temps fall below 120 F, allowing hydrocarbon condensation
- Since gas is lean, not much will condense
Liquid Dropout for 30 F Ambient Gas Well Sales – water only

Stream Summary

- Company: Ariel Corporation
- Case 1: 65 to 950
- Customer: EOG
- Project: BOSW Electric Driven

- 4993 MSCFD
- 25 MSCFD
- 4 MSCFD
- 2 MSCFD
How does this change for richer gas? 100°F Ambient (0.76 Gravity Eagle Ford)

- Temps kept above 120 F, no hydrocarbons condense
Phase Diagram for 30 F Ambient Liquids Rich Gas (0.76 Gravity)

- Temps fall below 120 F, allowing SIGNIFICANT hydrocarbon condensation since gas is richer
Liquid Dropout for 30 F Ambient 0.76 SG – 3.06% Hydrocarbons Condense

5105 MSCFPD
### Summary Table – Condensation as percentage of inlet gas volume

<table>
<thead>
<tr>
<th>Gas Type</th>
<th>Gas Gravity</th>
<th>Water Cond at 100 F Ambient</th>
<th>HC Cond at 100 F Ambient</th>
<th>Water Cond at 30 F Ambient</th>
<th>HC Cond at 30 F Ambient</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gas Well - Lean</td>
<td>0.65</td>
<td>0.46%</td>
<td>0</td>
<td>0.62%</td>
<td>0</td>
</tr>
<tr>
<td>Eagle Ford - Rich</td>
<td>0.76</td>
<td>0.59%</td>
<td>0</td>
<td>0.74%</td>
<td>3.06%</td>
</tr>
<tr>
<td>Permian – Rich</td>
<td>0.80</td>
<td>1.08%</td>
<td>0</td>
<td>1.27%</td>
<td>7.63%</td>
</tr>
<tr>
<td>Permian – Rich+</td>
<td>0.97</td>
<td>1.08%</td>
<td>12.38%</td>
<td>1.23%</td>
<td>23.72%</td>
</tr>
</tbody>
</table>

- Permian shows winter challenge of maintaining rich gas in vapor state
Impact of Liquid Dropout to Operations

• Frequent Interstage Scrubber Dumps
  
  – Lines cool as light ends re-vaporize
  
  – Freezes from inside-out, plugging line
  
  – Heat tracing and insulation helps prevent high level shutdowns
Condensed liquids to tank?

- Can overwhelm TVRU capability
  - 5% of 5000 MCFPD is 250 MCFPD (45 HP)
  - Results in excessive flaring, less gas sales
- Plumb interstage scrubbers to low pressure separator upstream of sales meter, relieving TVRU, reducing recycle
- Inlet and fuel scrubbers still dump to tanks
- **Are your compressors pre-plumbed for this?**
Impact of Liquid Dropout to Operations

- **Compressor output reduced**
  - Well performance suffers
  - Mitigate by oversizing compressor

- **Safety Issues**
  - Blowing down compressor sweeps liquids from horizontal piping onto location
    - Install slow rate auto blowdown into gas sales
  - Hydrates plug final cooler and discharge pipe
    - Inject Methanol
Presence of Liquid at Wellsites

– Reduces gas measurement accuracy

– Gas lift valves may handle slug of liquid
  • If centralized compression, slugging an issue
  • Significant slug may cut orifice, or multipoint

– Last well on common line may receive 100% of condensation
Obvious Solution: Prevent by Elevating Gas Temperatures

- Even super-rich 0.97 gravity gas can remain vapor with 150 to 180 F temps
What if temps could be kept in 100% Vapor range to the wellhead?

- Increased compressor uptime
- Minimize hydrate formation
- No increase in VRU load or flare emissions
- No need for methanol injection
- Warm corrosion chemicals work better
- No mess when blowing down compressor
- No need to oversize compressor
- Well performance improved
- Paraffin deposition prevented
Reality: Facility Engineers prefer old ways of centralized compression

- Pipelines may cool gas to earth temp ~ 70F

<table>
<thead>
<tr>
<th>Gas Type</th>
<th>Gas Gravity</th>
<th>Condensation %</th>
<th>BBL per MM</th>
</tr>
</thead>
<tbody>
<tr>
<td>Eagle Ford</td>
<td>0.76</td>
<td>3.85%</td>
<td>23.1</td>
</tr>
<tr>
<td>Permian - Rich</td>
<td>0.80</td>
<td>8.46%</td>
<td>52.4</td>
</tr>
<tr>
<td>Permian - Rich+</td>
<td>0.97</td>
<td>34.5%</td>
<td>216.6</td>
</tr>
</tbody>
</table>

- Some of this will re-vaporize as reaches downhole temps, but how much?

*Wellsite compression mitigates this problem*
Barriers to Maintaining High Temps

• Compressors designed for gas sales struggle to achieve high cooler outlet temps

• Cooler outlet temps not normally monitored, nor controlled
  – Pneumatic Kimray T-12 marginal control answer
  – Several better methods available

• Compressor industry thinks it’s not their problem, but operator gas quality issue
Breaking down these Barriers

• Educate yourself

• Look at the entire picture and not compartmentalize
  – Compressors impact entire facility operation

• Operators and compression companies need to address these problems jointly, perhaps in consortium environment

• Collaborative environment will result in multiple options, and good results
  – Improved safety, reliability, revenue, emissions
Suggested Changes

• Refine compressor packages designs to prevent hydrocarbon condensation
  – Reduce cooler sizes / alternative coolers
  – Install automatic cooler bypasses
  – Install automatic louver control systems

• Install near wells to prevent temp loss
  – Design injection piping to maintain elevated temperatures to wellhead
Conclusions

- Predictable hydrocarbon condensation occurs when compressing liquids rich gas, causing gas lift operating problems

- These problems can be solved by proper engineering design

- Old habits of facility engineers and most compressor rental companies adversely impact well performance, wellbore integrity, and economics, while increasing product losses, flare emissions, and safety risks
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