Niobrara, Horizontal Well Deliquifcation via Plunger Lift and Enhanced Controls Compression

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Principles of Operation

- Stabilize production by utilizing compression in conjunction with plunger lift
- Reduce required lifting force by artificially controlling flowing static pressure
- Decrease casing and tubing pressure differential
- Increase plunger cycle frequency
Well and Artificial Lift Profile

- Well Type: Horizontal
- Producing Formation: Niobrara
- Location: Lochbuie, Colorado
- Total Vertical Depth: 7,240’ (horizontal leg
- Lateral Length: 4,200’
- Collar Placement: +/- 40 degrees (~7,100’ MD)
- Plunger Type: 18”, 4 Slot Caged Bypass
- Compressor Type: 108mm Rotary Screw
- Compressor Driver: GM 5.7L Natural Gas Engine
Performance Without Compression

- Extended shut-in periods for building pressure
- Plunger non-arrivals due to excessive liquid loading
- Periodic swabbing to unload liquids
- Inconsistent production, requiring additional monitoring and intervention
Well Cycle Prior to Compression

• Average Casing Pressure: 467 PSI
• Average Tubing Pressure: 229 PSI
• Average Static Pressure: 134 PSI
• Average Plunger Arrival Time: 20.2 Minutes
• Tubing – Line Pressure Override: 195
• Average Afterflow: 4.12 Minutes
• Average Plunger Velocity: 248 Ft/Min
• Plunger Cycles Per Day: 33.75
Trend Prior to Compression

- Erratic production
- Substantial differential pressure between casing and tubing
- Frequent down time due to liquid loading
Performance With Compression

- 93% increase in plunger cycles per day
- Critical velocity maintained across all cycles
- Consistent plunger arrivals at reduced cycle duration
- Eliminated impact of fluctuations in gathering system pressure
Well Cycle With Compression

- Average Casing Pressure: 323 PSI
- Average Tubing Pressure: 178 PSI
- Average Static Pressure: 95 PSI
- Average Plunger Arrival Time: 14.6 Minutes
- Tubing – Line Pressure Override: 200
- Average Afterflow: .74 Minutes
- Average Plunger Velocity: 549 Ft/Min
- Plunger Cycles Per Day: 65
Trend Summary

- Stabilized production
- Reduced casing and tubing pressure differential
- No downtime associated with liquid loading
Production Impact

- Upward shift in decline curve
- Decline rate and daily average stabilized
- Compression costs offset by reduction in swab costs
- Improved labor efficiency
24 Hour View Without Compression

- Approx. 30 cycles per day
- Avg plunger arrival of 20 minutes
- Avg Static Pressure 130 psig
- Avg differential pressure 239 psig
24 Hour View With Compression

- Approx. 65 cycles per day
- Avg plunger arrival of 14.5 minutes
- Avg Static pressure 95 psig
- Avg differential pressure 145 psig
Performance Tables

### Averaged Comparison of Trend Data Points (September 8th to December 31st)

<table>
<thead>
<tr>
<th></th>
<th>Flow Rate (MCFPD)</th>
<th>Casing (PSI)</th>
<th>Tubing (PSI)</th>
<th>Static (PSI)</th>
<th>Arrival Time (Minutes)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to Compression</td>
<td>221.13</td>
<td>467.12</td>
<td>228.68</td>
<td>133.74</td>
<td>20.20</td>
</tr>
<tr>
<td>With Compression</td>
<td>244.68</td>
<td>323.11</td>
<td>178.16</td>
<td>94.97</td>
<td>14.66</td>
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<tr>
<td>Difference</td>
<td>23.55</td>
<td>144.02</td>
<td>50.52</td>
<td>38.77</td>
<td>5.54</td>
</tr>
</tbody>
</table>

### 2 Hour Average Comparison (September 27th vs November 11th)

<table>
<thead>
<tr>
<th></th>
<th>Tubing - Static Override</th>
<th>Tubing at Cycle Start</th>
<th>Casing - Tubing Differential</th>
<th>Static Pressure</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to Compression</td>
<td>196.00</td>
<td>330.23</td>
<td>245.04</td>
<td>135.77</td>
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<tr>
<td>With Compression</td>
<td>185.00</td>
<td>244.78</td>
<td>147.76</td>
<td>91.50</td>
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<tr>
<td>Difference</td>
<td>11.00</td>
<td>85.45</td>
<td>97.28</td>
<td>44.27</td>
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</tbody>
</table>

### 2 Hour Average Comparison (September 27th vs November 11th)

<table>
<thead>
<tr>
<th></th>
<th>Arrival Time (Minutes)</th>
<th>Cycles Per Day</th>
<th>Shut In Time (Minutes)</th>
<th>Plunger Velocity (Ft/Min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prior to Compression</td>
<td>28.67</td>
<td>33.75</td>
<td>14</td>
<td>248</td>
</tr>
<tr>
<td>With Compression</td>
<td>13.00</td>
<td>65.45</td>
<td>9.00</td>
<td>546</td>
</tr>
<tr>
<td>Difference</td>
<td>15.67</td>
<td>31.70</td>
<td>5.00</td>
<td>299</td>
</tr>
</tbody>
</table>
Gathering System Pressure Spike

- Compressor telemetry data
- Midstream pressure surged from 150 psig to 300 psig
- Upstream pressure maintained throughout the period
Gathering System Pressure Spike

- Consistent plunger cycles
- No missed plunger arrivals
- Stable tubing and casing pressures

December 1st, to December 3rd, 2015

Midstream Pressure Spike
150 psig to 300 psig
Questions?
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