A Paradigm Shift in Casing Design for Unconventional Wells

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Outline

- Make Artificial Lift/Production a Priority
- Production Lifecycle Anticipations
- Altering Lift Application Perception
- Simulations and Anticipated Results
- New Casing Separation Technology
Production Equipment Advances

- *Artificial lift in North America onshore: evolution, not revolution*
- McKinsey & Company

The first challenge is an operator mindset that often deprioritizes production phase services like artificial lift. Additional investment in more complex well designs (e.g. deeper wells, longer laterals), higher quality completions equipment, and larger volumes of proppant is viewed as a prudent expense that will increase a well’s estimated ultimate recovery (EUR) and boost an operator’s profitability. While outfitting a well with premium lift equipment can reduce intervention frequency and moderately increase production rates, the value of increased investment in artificial lift in a highly price-sensitive environment is less clear to operators.

Liquid Loading in Unconventionals

Production Decline

Top 8 Bakken Operators Comparison By Year of 1st Production

- 2016 Declining Faster Than Other Years Despite Higher Cumulative Production
- 2015 Declining Faster Than Other Years

Months of Production

Gas Related Challenges Keep Coming

Bakken ND - Average Gas to Oil Ratio by date
Confidential months are not included
Based on NDIC data, February 2016

9 Years

New Technology / Process

New AL Gas Separation Technology Applied Downhole

- 34 months
- 5 months

<table>
<thead>
<tr>
<th>Avg post install 5 mth</th>
<th>86.3</th>
<th>92.5</th>
<th>294.1</th>
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<tbody>
<tr>
<td>Avg pre install 1 yr</td>
<td>28.5</td>
<td>47.9</td>
<td>145.8</td>
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<tr>
<td>Improvement</td>
<td>203%</td>
<td>93%</td>
<td>102%</td>
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<tr>
<td>Added Revenue</td>
<td>$476,850</td>
<td></td>
<td>$66,735</td>
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Production Lifecycle – Altered…

[Graph showing production decline with projected values for different lifecycles:
- Online 24 month Incremental Projections:
  - High 16% Gain: $1,628,788
  - Mid 12% Gain: $1,221,591
  - Low 8% Gain: $814,394
- Online 36 month Incremental Projections:
  - High % Gain: $2,089,330
  - Mid % Gain: $1,566,998
  - Low % Gain: $1,044,665]
Highly Efficient Production

![Graph showing Inflow Performance Relationship (IPR) and Tubing Performance Curve (TPC = VLP). The graph illustrates static pressure declining with time and the points where flows are free, pumped, or at future pumped rates.](http://frontender.com/blog/wp-content/uploads/2014/08/WellPerformanceOptimization-1024x758.jpg)
Lifting Instead of Suppressing

- Permian - Wolfcamp - High Liquids Producer

Gas Incremental 12%

Oil Incremental 12%

Online 24 month Incremental Projections

- $4,239,845 High 16% Gain
- $3,179,883 Mid 12% Gain
- $2,119,922 Low 8% Gain
Casing Gas Separator (CGS)
How is This Achieved?

- Utilize wasted open-hole space to your advantage
- Create artificial “sump” in wellbore; like vertical well
- Create maximum separation capacity/process and improve Peak Performance Envelope
- There is no compromise for adding significant separation area to a wellbore
Downhole Gas Separation System

CGS Simple RP Set up

5.5” Casing Max Separation Capacity: ~600 bfpd

VS.

5.5” x 7” CGS Max Separation Capacity: ~1300 bfpd
Computational Fluid Dynamics

Bottom

Top
CGS+ESP Nodal Analysis

Well #1H

Across Top Ports w/ ESP

Across Top Ports w/ 4” ESP

Above Top Ports w/ ESP

Traveling Up Inside CGS

Traveling Up Inside 7”x5.5” CGS

3.0MMcfd, 3000bfpd, 1000#PIP, 50% oil cut

Conclusion

- CGS is the most cost-effective and low-risk, solution that allows real performance and profit altering results.

- Ease and breadth of application can provide significant low-cost/high-reward benefit.

- The industry is far overdue for a technological advancement on this front as it relates to horizontal wells.
Questions

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Pre: 2.5MM, 4600 bfpd, 25% oil cut  
Post: 2.8MM, 5200 bfpd, 25% oil cut
CGS + Echometer UPS

5.5” Casing Max
Separation Capacity:
~600 bfpd

VS.

5.5” x 7” CGS Max
Separation Capacity:
~1300 bfpd
CGS + Desander

5.5” Casing Max Separation Capacity: ~600 bfpd

VS.

5.5” x 7” CGS Max Separation Capacity: ~1300 bfpd
CGS Results

- Creates “route-around” for all gas to be avoided
- Greatly increase drawdown capability without generating interference
- Eliminate slugging at the pump, thus limits on-off cycling and inherent problems:
  - Sand fallback in all forms
  - Stuck pumps in all forms
  - Heat cycling in ESPs
- Reduce failures and downtime as well as lost/deferred revenues