Stand-alone Thru-tubing Dynamic Underbalance Application to Improve Existing Well Productivity

Authors: Lester Tugung Michael & Adil Busaidy

APPS-21-18
Agenda

1. Technology Introduction
2. Candidate Screening
3. Well XS Implementation
4. Well YS Implementation
5. Conclusion
Technology Introduction

Stand-alone Thru-tubing Dynamic Underbalanced Application

- An implosion chamber is placed across the interval to be treated, creating short-lived dynamic underbalance to clean perforation tunnels.
Candidate Screening Process

- Production profiles
- Open hole logs
- Well integrity reports
- Well intervention history
- Completion requirement
- Perforation designs
- Data acquisition (PTA, PLT, MIT, RST, etc.)

Basic candidate screening workflow for stand-alone thru-tubing dynamic underbalanced application
Candidate Selection Stages

First Stage Screening
186 Strings

- String status (active and idle)
- Screen out depleted idle status (reached economic limit)
- Screen PI and production history for active strings
- Screen out wells that have any future PE plan

Completion Requirement:
- 2.3” < tubing ID/restriction < 3.5”.
- Direct access to perforation interval
- No permanent sand control (e.g. GP)

Second Stage Screening
51 Strings

Subsurface Requirement:
- Static Res. Press > 1000 psi
- Perm > 50 mD
Candidate Selection Stages

Third Stage Screening
19 Strings

- Reservoir type (unconsolidated vs. consolidated)
- Rock UCS
- Sand tendency
- Critical drawdown pressure and water cut

Technical gate approval – Full Candidate Analysis
- Well & production history
- Subsurface evaluation (cross section, map, logs, fluid contacts)
- Reserves calculation (volumetric & DCA)
- Nodal analysis and perforation evaluation
- Economics
- Summary of job procedure

Fourth Stage Screening
2 Strings
Well XS Implementation

**Well status:** Well is depleting, reaching its economic limit (~50 bopd)

**Solution:** Thru-tubing DUB pilot to stimulate upper layer. Lower risks due to low depleting production

**Selective Treatment:** Top 12 ft, ~900 psi DUB(*) applied in 2.5”, 30-ft chamber (20-ft loaded)

(*)Dynamic Underbalance

4788 Ft MDKB

DUB treatment (12 ft)

4808 Ft MDKB

Stand-alone Thru-Tubing Dynamic Underbalance Application to Improve Existing Well Productivity
WELL XS (Sand A) Implementation

Reverse Perforation Evaluation (Before Thru-tubing DUB)

- Current effective perforation tunnels length show only ~30% of the total tunnel length are contributing to flow.

<table>
<thead>
<tr>
<th>Perf. #</th>
<th>Loaded Length (ft)</th>
<th>Phasing Angle (deg)</th>
<th>Shot Density (spf)</th>
<th>Eff. Shot Density (spf)</th>
<th>Clean Length Le/L</th>
<th>Form Pen Avg (in)</th>
<th>Form Dia Avg (in)</th>
<th>EH Dia Avg (in)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>20.0</td>
<td>0 (360)</td>
<td>8.00</td>
<td>8.00</td>
<td>0.28</td>
<td>2.47 *</td>
<td>0.26</td>
<td>0.10</td>
</tr>
</tbody>
</table>

* Rock-based Model: Based on lab experiments in rocks with UCS up to 18k psi under downhole conditions

<table>
<thead>
<tr>
<th>Perf. #</th>
<th>Eff. Skin</th>
<th>Pi * (STB/day/psi)</th>
<th>Flow * Rate (STB/day)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>15.84</td>
<td>0.99</td>
<td>512.4</td>
</tr>
</tbody>
</table>

Stand-alone Thru-Tubing Dynamic Underbalance Application to Improve Existing Well Productivity
WELL XS (Sand A) Implementation

Thru-tubing DUB Results

<table>
<thead>
<tr>
<th>Well XS</th>
<th>Before</th>
<th>After</th>
</tr>
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<tbody>
<tr>
<td>Gross Rate (blpd)</td>
<td>410</td>
<td>828</td>
</tr>
<tr>
<td>Oil Rate (bopd)</td>
<td>82</td>
<td>166</td>
</tr>
<tr>
<td>WC (%)</td>
<td>80</td>
<td>80</td>
</tr>
<tr>
<td>Productivity Index (STBD/psi)</td>
<td>0.8</td>
<td>1.7</td>
</tr>
<tr>
<td>UEC ($/bbl)</td>
<td>9.65</td>
<td></td>
</tr>
</tbody>
</table>

Instantaneous Gain

~80 bopd

PI doubled from 0.8 to 1.7 STBD/psi

Stand-alone Thru-Tubing Dynamic Underbalance Application to Improve Existing Well Productivity
WELL XS (Sand A) Implementation

Reverse Perforation Evaluation (After Thru-tubing DUB)

- The new effective perforation tunnels show 100% of the total tunnel length are contributing to flow

### Perforating System(s)

<table>
<thead>
<tr>
<th>Perf #</th>
<th>Loaded Length (ft)</th>
<th>Phasing Angle (deg)</th>
<th>Shot Density (spf)</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td>7.47</td>
<td>1.62</td>
<td>805.5</td>
</tr>
</tbody>
</table>
**WELL YS (Sand B) Implementation**

**Problem:** Rapid production decline in the last 12 months

**Data Acquisition - PLT:** Only 33% of the 30 ft interval is contributing to flow. 66% had no flow

- 5% of Qtot (5 ft)
- Sand B (30 ft)
- 95% of Qtot (5 ft)

![Diagram showing the wellbore schematic with depth intervals and production data](image)
WELL YS (Sand B) Implementation

Solution – Selective Thru-tubing DUB Treatment:
- A nippleless plug was installed to isolate lower zone
- Treat top 10 ft, ~ 1000 psi DUB(*) applied in 2.5”, 30-ft chamber (20 ft loaded)

Debris analysis:
- 73% formation sand (good tunnel cleaning)

5% of Qtot (5 ft)

95% of Qtot (5 ft)
WELL YS (Sand B) Implementation

Reverse Perforation Evaluation (After Thru-tubing DUB)

- Current effective perforation tunnels show only 32% of the total tunnel length are contributing to flow

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<tr>
<td>1</td>
<td>5.0</td>
<td>0 (360)</td>
<td>8.00</td>
<td>0.32</td>
<td>5.79 *</td>
<td>0.31</td>
</tr>
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* Rock-based Model: Based on lab experiments in rocks with UCS up to 18k psi under downhole conditions

### Formation

- Rock Type: Sandstone
- Porosity: 21.8%
- Horizontal Permeability: 220.00 md
- Vertical Permeability: 22.00 md
- kd/k: 0.25
- Wellbore Damage: 8 in
WELL YS (Sand B) Implementation

Thru-tubing DUB Results

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<td>Gross Rate (bfpd)</td>
<td>1145</td>
<td>2307</td>
</tr>
<tr>
<td>Oil Rate (bopd)</td>
<td>344</td>
<td>449</td>
</tr>
<tr>
<td>WC (%)</td>
<td>70</td>
<td>80</td>
</tr>
<tr>
<td>Prod Index (STBD/psi)</td>
<td>4.1</td>
<td>4.7</td>
</tr>
<tr>
<td>UEC ($/bbl)</td>
<td>8.66</td>
<td></td>
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</tbody>
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Instantaneous Gain
~100 bopd

PI increased from 4.1 to 4.7. GLVC was conducted to optimize lifting due to increased WC
WELL YS (Sand B) Implementation

Reverse Perforation Evaluation (After Thru-tubing DUB)

- Result: **Additional 3 ft** of perf interval is now contributing to flow (total 8 ft) with the effective perforation tunnels length **100%**

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<th>Flow Rate (STB/day)</th>
</tr>
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<tbody>
<tr>
<td>1</td>
<td>11.17</td>
<td>10.76</td>
<td>0.52</td>
<td>254.8</td>
</tr>
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<tr>
<th>Well Ys</th>
<th>Oil Rate (bopd)</th>
<th>Perf Int (ft)</th>
<th>PI (stdl/psi)</th>
</tr>
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<tbody>
<tr>
<td>Before</td>
<td>57</td>
<td>5</td>
<td>0.15</td>
</tr>
<tr>
<td>After</td>
<td>254</td>
<td>8</td>
<td>0.52</td>
</tr>
<tr>
<td>Increment</td>
<td>197</td>
<td>3</td>
<td>0.37</td>
</tr>
</tbody>
</table>

Stand-alone Thru-Tubing Dynamic Underbalance Application to Improve Existing Well Productivity
Conclusion

1. Instantaneous gain: 180 bopd from thru-tubing DUB application
2. Cost optimization (~9 USD/bbl)
3. New technology introduction in Field S
4. Increased perforation efficiency
5. Studies of impact of watercut increase and sand production are needed
QUESTIONS?
THANK YOU!