Mangrove Design Software Increases Total Stimulated Volume 25% in Marcellus Shale

Engineered completion designs help Seneca Resources increase initial flow rates 35% while lowering treating pressures and saving time.

**CHALLENGE**

Improve hydraulic fracture coverage—and production rates—from heterogeneous horizontal wells where stimulation treatments tend to flow to lowest-stressed zones.

**SOLUTION**

Use cased hole Sonic Scanner* and RST* reservoir saturation tool measurements tracted into the lateral, along with Mangrove* reservoir-centric stimulation design software to engineer perforation locations and help distribute stimulation treatments more evenly.

**RESULTS**

Realized 25% more stimulated volume and 35% higher initial gas flow rates than in offset well with geometric perforation cluster placements.

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**Seneca Resources needed to maximize reservoir contact in heterogeneous wells**

The Marcellus shale consists of many thin laminations, each with its own distinct mechanical properties. As a lateral well traverses through these laminations, a large amount of lateral heterogeneity appears along the wellbore. Because of this, significant production variability exists between seemingly identical wells. This observed heterogeneity also contributes to completion problems such as increased screenout rates, high treating pressures, and extended pump times. To mitigate some of these challenges, Seneca Resources partnered with Schlumberger for a three-well, proof-of-concept test comparing an engineered completion methodology with the conventional approach.

**Engineers delivered customized completion designs in under an hour**

Well A used geometric perforation spacing, while Wells B and C used engineered designs. For consistency, all three wells were

- drilled from the same pad location
- drilled in the same direction
- drilled to similar lateral lengths
- placed in the same target zone
- spaced approximately 800 ft apart.

Schlumberger conveyed RST reservoir saturation tool and Sonic Scanner acoustic scanning tool on wireline to help determine lithology and stresses along the laterals. Mangrove software allowed engineers to analyze the data and develop optimized completion strategies for wells B and C in under an hour. The three wells were stimulated simultaneously using the “zipper-frac” approach, which alternated stages between wells. While one well was being fracted, a second team performed plug-and-perf operations on the next well.

**Operator increased stimulated volume 25% and initial gas flowback rates 35%**

StimMAP LIVE* real-time microseismic monitoring service showed that approximately 35% of the perforation clusters in the lateral portion of Well A had little to no microseismic activity. In contrast, only 20% of the perforation clusters in Wells B and C had little to no microseismic events. On a per-foot basis, Well B, which was approximately the same distance from the monitor well as Well A, had 25% more stimulated volume.

Initial gas flowback rates of Wells B and C were respectively 33% and 40% higher than the rate of well A on a ¾-in choke. In addition, Seneca Resources realized lower treating pressures at higher pump rates, leading to lower operational risk. As a result, Seneca Resources has continued to use microseismic data to evaluate treatments and has obtained lateral measurements in additional wells to engineer completion designs with Mangrove software.
**CASE STUDY:** Mangrove design software increases total stimulated volume 25% in Marcellus shale

StimMAP LIVE data from Well A and Well B show a side view of microseismic events in relation to cluster placement. The histograms show the density of microseismic events at various stages along the lateral. Data indicate many understimulated clusters in Well A and much more even coverage along the lateral of Well B.

<table>
<thead>
<tr>
<th>Well</th>
<th>Completion Method</th>
<th>Average Breakdown Pressure, psi</th>
<th>Average Treating Pressure, psi</th>
<th>Average Treatment Rate, bbl/min</th>
<th>Proppant Placed versus Design</th>
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</thead>
<tbody>
<tr>
<td>A</td>
<td>Geometric</td>
<td>5,572</td>
<td>7,277</td>
<td>69.7</td>
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<tr>
<td>B and C</td>
<td>Engineered</td>
<td>5,160</td>
<td>7,095</td>
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<tr>
<td>Difference</td>
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<td>93%</td>
<td>97%</td>
<td>116%</td>
<td>122%</td>
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