The Evolution of CT Fracturing Techniques in Western Canada

SPE ICOTA Roundtable
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Outline

• Industry Trends

• Overview of Different Techniques (with a focus on doing more with less)
  – Sandjet Perforating & Packer
  – Frac Sleeves
  – Straddle Systems
  – The Half Straddle™
Outline

• Process Efficiency
  – Reduce fluid consumption
  – More done in less time
WCSB Industry Trends

![Graph showing total stages over time from 07/2009 to 09/2011.]
WCSB Industry Trends

Stage Spacing

Time

Stage Spacing (m)

07/2009  08/2010  09/2011
Packer & Sand Jet Perforating

• Broad market application since 2009
  – >1000 wells & 10,000 zones in WCSB

• Expanding into new markets
  – Deeper Wells @ higher pressures

• “The most successful people are those who are good at Plan B” James Yorke (1941-)
  – Process contingency for Screen Outs
  – Feedback to adapt on the fly
Sand Jet Perforating & Packer

1. Sand Jet Perforating Sub
2. Equalizing Valve
3. Packer and Anchor Assembly
4. Mechanical Casing Collar Locator (MCCL)
Packer & Perforating System

Run in hole, locate collars with Mechanical Casing Collar Locater (MCCL)

Set BHA in the toe of the well
Packer and Perforating System

Circulate abrasive slurry through perforator (Fluid Volume = 4 m³)

Circulate to slurry up the well away from perforations (Fluid Volume = 2 m³)
Packer and Perforating System

Pump fracture stimulation fluids down the annulus

- Deadleg for Real Time Bottom Hole Pressure
- Annulus flow supports large Flow Rates

Fluid Volumes (typical Bakken well)

- Perforating = 6 m³
- Pad = 5.5 m³
- Place Proppant = 11 m³
- Flush = 5 m³
- Total/Stage = 27.5 m³
CT Frac Sleeves

• Broad Market Application since 2010
  – More than 5000 Stages in over 300 wells
• Refinement of the Packer and Sand Jet Perforating Technique
• Sand jet perforation tunnels replaced by the CT Frac Sleeves
CT Frac Sleeve

Fluid Volumes (same typical Bakken well)

- Perforating = 0 m³
- Pad = 5.5 m³
- Proppant = 11 m³
- Flush = 5 m³
- Total/Stage = 21.5 m³
Straddle System

• Market Application
  – Refrac existing wells
  – Add stages between existing stages
  – New well construction
    • Explosive Perforating, Burst Ports, Frac Sleeves

• Benefits
  – Complete zonal isolation

• Limitations
  – Pump frac down CT
  – Limited circulation capabilities (limited Plan Bs even for MacGyver)
Straddle System

• Fluid Volumes
  • Perforating = 0 m³
  • Pad = 8 m³ (CT Volume)
  • Proppant = 11 m³
  • Flush = 0 m³
  • Total/Stage = 19 m³
Half Straddle™

- Modification of Packer & Sand Jet Perforating Technique
- Frac Stimulation Fluid pumped down the CT
- Sand Jet Perforator replaced with frac sub
- Use with Frac Sleeves (perforating not required)
- Similar to Straddle BHA technique without the top cup
Half Straddle™ Technique

Fluid Volumes
- Perforating = 0 m³
- Pad = 2 m³ (CT Volume)
- Proppant = 11 m³
- Flush = 0 m³
- Total/Stage = 13 m³
# Fluid Volume Comparison Summary

<table>
<thead>
<tr>
<th>Frac Technique</th>
<th>Fluid Savings Stage Volume m³</th>
<th>Fluid Savings x 25 Stages m³</th>
<th>Fluid Reduction %</th>
<th>% Time per Stage *</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Half Straddle™</strong>&lt;br&gt;vs. Packer &amp; Sand Jet Perforating</td>
<td>14.5</td>
<td>363</td>
<td>47%</td>
<td>44%</td>
</tr>
<tr>
<td><strong>Half Straddle™</strong>&lt;br&gt;vs. CT Frac Sleeves</td>
<td>8.5</td>
<td>213</td>
<td>39%</td>
<td>72%</td>
</tr>
<tr>
<td><strong>Half Straddle™</strong>&lt;br&gt;vs. Conventional Straddle</td>
<td>6</td>
<td>150</td>
<td>31%</td>
<td>79%</td>
</tr>
</tbody>
</table>

* No unplanned events
Conclusions

• CT is having a significant impact on creating new and improving processes for multi-stage fracturing techniques
  – Time savings and fluid reductions
  – Improving productivity
Questions?

- ICOTA
- NCS Oilfield Services
- Geo Webworks Inc.