What is the Frac Load Fluid Recovery?

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What is the Frac Load Fluid Recovery?

Source: Don Leblanc, Eastex Petroleum Consultants Inc.
What Causes Poor Frac Load Recovery and the Resulting Short Effective Fracture Length
- Water block due to Imbibition – A Function of Surface Tension
- Water interaction with clays and formation minerals
- Water is immiscible with Hydrocarbons (2 phases)
- Flooding of the reservoir with water
- Hydrocarbon break thru prior to total clean up
Industry Issues
Case Study San Miguel Formation

- Depth 3,750 ft
- Bottom-hole pressure of 1650 psig (.44 psi/ft)
- Bottom-hole temperature 140 degree F
- Tight oil sand gross pay of 90 ft, high porosity pay section of 27 ft.
- Perm of .05 - .10 md
- Water saturation of 45%
- Oil gravity 45 degree API, Gas is over 8 gpm
- Field has over 200 vertical wells. Average IP of 15 bpd and EUR of 15 Mbbl.
<table>
<thead>
<tr>
<th></th>
<th>Water</th>
<th>NGL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Volume</td>
<td>4,797 bbls per stage</td>
<td>1,675 bbls per stage</td>
</tr>
<tr>
<td>Weight</td>
<td>85,569 lbs. per stage</td>
<td>90,924 lbs. per stage</td>
</tr>
<tr>
<td>Frac gradient</td>
<td>.94 psi/ft</td>
<td>Frac gradient .96 psi/ft</td>
</tr>
<tr>
<td>Treating Rate</td>
<td>66 BPM</td>
<td>Treating Rate 40 BPM</td>
</tr>
<tr>
<td>Stages</td>
<td>9 stages per well</td>
<td>10 stages per well</td>
</tr>
</tbody>
</table>
San Miguel: Cumulative BOE vs Time

- **BOE** vs **Days**
  - Scale: 0 to 60000
  - Days: 0 to 180

Lines:
- **Gas Frac Average**
- **Water Frac Average**
San Miguel: Rate vs Time
Ideal Fracture Fluid: Hydrocarbons

Advantage of LPG’s and Hybrid Hydrocarbon Fluids

Properties: Leading to Higher % Recovery of in Place Hydrocarbons, Immediate Load Recovery time, production and Enhanced Oil Recovery (EOR)

Low Viscosity
- Lower Surface Tension
- Solubility/Miscibility in formation hydrocarbons
- Lower density (Higher Drawdowns)
- No interaction with formation clays or minerals

Hydrocarbons fluids can be recovered and sold for cost recovery

These hydrocarbon properties can be engineered to enhance production, and facilitate recycling / cost recovery of the fracturing fluid
How do I make a business case for using hydrocarbon fluids as a fracturing fluid when:

- Water cost pennies per gallon
- Hydrocarbon fluids cost dollars per gallon
San Miguel: 90,000 lb/stage Frac Economics

<table>
<thead>
<tr>
<th></th>
<th>Water Frac</th>
<th>NGL Frac</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pump</td>
<td>$110 K</td>
<td>$120 K</td>
</tr>
<tr>
<td>Frac Fluid</td>
<td>$18 K</td>
<td>$196 K</td>
</tr>
<tr>
<td>H2O Transfer</td>
<td>$7 K</td>
<td></td>
</tr>
<tr>
<td>Disposal</td>
<td>$5 K</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>$140 K/stage</td>
<td>$316 K</td>
</tr>
</tbody>
</table>

Recovery: $(148 K)

Net Cost: $168 K/stage

- Recovery is key to making economics work
- Expect to reduce net cost to $120K/stage by sourcing less expensive fluids
<table>
<thead>
<tr>
<th>Frac Type</th>
<th>Average IP (BOE/d)</th>
<th>Wells</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Frac</td>
<td>90,000 lbs</td>
<td>2</td>
</tr>
<tr>
<td>Propane Frac</td>
<td>90,000 lbs</td>
<td>4</td>
</tr>
<tr>
<td>C4 + Frac</td>
<td>90,000 lbs</td>
<td>4</td>
</tr>
<tr>
<td>Small Hybrid frac</td>
<td>90,000 lbs</td>
<td>1</td>
</tr>
<tr>
<td>Large Hybrid Frac</td>
<td>183,000 lbs</td>
<td>4</td>
</tr>
</tbody>
</table>

Is it Scalable?
As of Dec 2013: 2314 Fracs on 722 Locations

- Largest job to date: 2.6 MM lb, 10 + stage
- Highest pressure treatment to 13,050 psi (Lowest: 362 psi)
- Treating rates to 50 bbl/min & proppant concentrations to 8 lb/gal
- Oil, Gas, and Condensate wells
- Deepest Treatment to over 13,000 ft TVD
- Formation Temperatures from 54 °F to 300 °F

Gasfrac: Focused on Safety, Engineered Hydrocarbon Fracture Fluids & Fit for Purpose Equipment
Gelled 100% LPG Fracturing Process

Typical LPG Equipment Spread

<table>
<thead>
<tr>
<th>Fluid</th>
<th>LPG 4,000 bbl (170,000 gal)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Proppant</td>
<td>20/40 mesh sand 200,000 lb</td>
</tr>
<tr>
<td>Pumping</td>
<td>11,500 HHP, 30 bpm</td>
</tr>
</tbody>
</table>
Hybrid LPG Fracturing Process

A Scalable LPG Fracturing Process – Increase Proppant Delivery

Two Streams Commingled at the Wellhead
  - LPG
  - Hybrid Fluid and Sand

This Is Done with the Knowledge Gained from 100 % LPG Fracturing

Typical Hybrid LPG Equipment Spread

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluid</td>
<td>Plus 11,000 BBLs</td>
</tr>
<tr>
<td>Proppant</td>
<td>Plus 720,000 lb</td>
</tr>
<tr>
<td>Pumping</td>
<td>60 bpm</td>
</tr>
</tbody>
</table>
Pros and Cons

Pros

More Productive Wells
- Provide energy to help lift frac fluid and reservoir fluids. It does this while also remaining in liquid phase while treating the well.
- Higher initial IP’s.
- Increased long term production.
- Enhanced recovery rates.
- Minimized flaring - immediate to gas sales.
- Does not cause clay swelling.
- Maintains higher relative permeability to oil.

Flowback
- Turn a liability into an asset.
- Engineered hydrocarbon frac per facilities.
- Quicker for wells to clean up.
- Low surface tension help during flowback.

Lower Life Cycle of Well Costs
- Chemical Costs – no water and no resulting introduction of SRB’s.
- Pigging.
- Facility upsets.
- No investment in water handling infrastructure, as with water fracs.

Potentially Fewer Wells
- Larger effective drainage area.

Low Environmental and Ecological Impact
Pros and Cons

Cons

Costs
- Higher AFE number for completions.
- Flowback – integration of flowback equipment for recovery.

Safety Concerns
- Built for purpose equipment.
- Compartmentalize and flare any problems.
- More redundancy and backups than with water fracs.
- Maintenance process to maintain equipment specifications.
- LEL monitors.
- Thermal cameras in the hot zone.

Logistics
- Availability of NGL frac fluids.
- Wellbore Configuration - open hole vs plug and perf packers.
- Job size.