Contents

- Introduction to the technology
- Testing and field experience
- Field Applications and considerations
- Conclusions
Sand Production: Summary

Sand production causes a number of problems and leads to increased costs

Where anticipated, it can be addressed by the use of appropriate well completions
  - May not be economical to retro-fit or re-complete well

Chemical sand consolidation technologies may provide the solution in some cases

Difficulties with many existing approaches:
  - Can cause significant loss in oil productivity or require re-perforation
  - Not environmentally acceptable
  - Not all field proven
Chemical approach – rigid vs soft SCON
Strength required to cut groove in core can be correlated to UCS value

Response gives a profile even at very low UCS values
Nalco Champion chemical sand consolidation technology - SECURE SC2020

Key deployment features:
- Targets moderate increase in sand strength with minimum loss in permeability
- Deployed using simple process from dilute solution in diesel
- Environmentally acceptable
- Designed to allow increased production from wells on Maximum Sand Free Rate
- Field proven with >150 applications globally
Introduction to the Technology

- Oil soluble organo-silane, supplied as concentrate in protective atmosphere
- Dissolved in diesel prior to application, typical concentration 4 – 7% v/v
- Molecule contains hydrolysable leaving groups
  - Reaction driven by hydrolysis and increase in temperature
- On contact with in-situ reservoir water:
  - Hydrolysis changes functional groups from silane to silanol
  - Changes chemistry from oil soluble to water soluble
  - Drives partition to water phase
  - Yields molecule with active silanol sites
- Silanol groups form strong attachment to sand grains via primary chemical bonds
- Further reactions lead to formation of flexible visco-elastic network within water phase
Simple Application Strategy

- Diesel spearhead to reduce to Swi layer around sand grains
- Injection of Main Pill and placement
- Shut-in – to allow reaction phases
- Controlled return to production

[Swi - Irreducible Water saturation]
Topside arrangements for a deployment

From Rig
- Bullhead, or
- Coiled Tubing
From Platform (space permitting)

Example Pump Layout

Coiled Tubing Example

Active Chemical
Case History – Horizontal Well A, Norway

- Production rate doubles after treatment
- Additional revenue ~ USD 50,000/day (based on 40 USD / bbl)
- Treatment lasts >10 months
- Stable through shutdown periods
- Presented in SPE112397
Treatment Value, Field B, UK – ROI

Field B - Restoration of Shut in Well-Value Against Total Mobilisation Cost (estimates)

- Based on 3200 BOPD at $40 per barrel
- Total SCON treatment costs <20% of Mob cost (est)
Qualification for Trial
Qualification Methodology

- Discuss Field/Well suitability with Client
  - Agree qualification programme

- Prepare core to representative Swi and water saturation cycle

- Perform coreflood using concentration (1)
  - Determine pre-and post-treatment permeabilities

- Repeat using same procedure using concentration (2)

- Repeat using same concentration with no active chemical (control)

- Perform rock mechanics tests on control and test samples

- Feed qualification results into treatment design
  - Initial optimization
Qualification for Field Trial

<table>
<thead>
<tr>
<th>Treatment Concentration</th>
<th>Permeability Reduction (90°C)</th>
<th>Rock Strength (MPa)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Control</td>
<td>N/A</td>
<td>4.0 - 5.3 (No Gradient)</td>
</tr>
<tr>
<td>6%</td>
<td>17%</td>
<td>6.6 – 7.5 (No Gradient)</td>
</tr>
</tbody>
</table>

- Actual field perm. reduction is reported as less than Coreflood perm reduction.
- No specific impact frequently reported.

Control

6% Treatment +50% strength
Global Examples
Multizone/Layers Treatment - Indonesia

- Loose sands – layered zones
- Short intervals
- Different completion types
  - Gravel pack
  - Perforations
  - Mixed
- Different treatment approach used for different zones
  - Re-pack
  - Resin – if temperature zone okay
  - Soft SCON
Multizone Treatment – Asia Pacific

- Treatment by Coiled Tubing/Barge
- Cleanouts followed by placement
- Batch Mix approach
- Higher concentration
  - Formation damage tolerable compared to sand production impact
- Issues with
  - Diesel dryness
  - Dewatering lines and mix tank
    - Dead legs and flushing
  - Cleaning mix tank beforehand
Indonesia Treatment Outcomes

- Focus on minimising sand production.
  - Some hydrocarbon gain from some zones.
- Good longevity – retreated after 10 months with no issues
- Total presented paper at conference – June 2015
Where has it been Used?

- Wells on Maximum Sand Free Rate
- Wells unable to produce at a MSFR (shut-in)
- High value and low value wells (based on production rates)
- Perforated wells
- Sand Screen wells
- Wells with failed Expandable Sand Screens
- Prior to a Scale Squeeze
- After a Scale Squeeze
- As part of a routine application programme (6 treatments on one well)
- Vertical and Horizontal orientations
- All water cuts (dry oil to 100% water in well)
- Up to 150m intervals in single deployment
- Bullhead and Coiled tubing deployment
Thank You For Your Attention

Questions?