UNCONVENTIONALS

CASE STUDY

LSNAF System Increases Productivity in HPHT Wells

CUSTOMIZED FLUID SYSTEM REDUCES FORMATION DAMAGE AND SAVES OPERATIONAL TIME

NORWEGIAN SEA, NORWAY

CHALLENGE

Improve the well's poor productivity index by finding a specific drilling fluid that would withstand ranging temperatures of 302°F to 329°F (150°C to 165°C) while also providing:

- Minimal formation damage
- Wellbore stability
- Low ECD
- No barite sagging
- Excellent lubricity

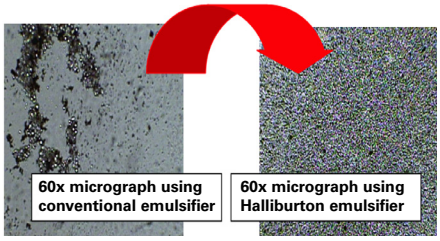
SOLUTION

- Low-viscosity LSNAF system as a drill-in reservoir fluid
- BARACARB® and STEELSEAL® LCM, formulated using WellSET® lost circulation treatment to improve wellbore strength

RESULTS

- Reduced formation damage, thus increasing return permeability by 50 percent when compared to conventional non-aqueous drilling fluids
- Achieved major increase in productivity after successful completion of the well

OVERVIEW



Photomicrograph showing emulsified droplets. Left picture shows agglomeration and coalescence of droplets when using a conventional emulsifier in dense brine at low oil/water ratio. The picture on the right, in contrast, shows much smaller and evenly dispersed droplets when using a Halliburton emulsifier.

In 2011, the operator's field in the Norwegian Sea was characterized as being a high-pressure/high-temperature (HPHT) field with low-permeability sandstone. The strategy for this particular field includes multilateral well design with long horizontal sections that are sometimes drilled using through-tubing rotary drilling (TTRD) technology.

The operator challenged Halliburton to improve the well's poor productivity index by finding a specific drilling fluid that can provide minimal formation damage, wellbore stability, low equivalent circulating density (ECD), no barite sagging and excellent lubricity. Because the reservoir has ranging temperatures of 302°F to 329°F (150°C to 165°C), the well required a thermostable drill-in fluid instead of the conventional non-aqueous fluid systems that were being used.

Core analysis studies for this field demonstrated poor return permeability values when conventional barite-weighted, non-aqueous fluid systems were investigated. These results are consistent with formation damage theories related to small particle migration within pore spaces impeding flow after internal mud cakes have been created.

SOLUTION

After planning and rigorous testing, Halliburton chemists designed a low-viscosity, low-solids, non-aqueous fluid (LSNAF) system that fulfilled the operator's challenges as a drill-in reservoir fluid.

The LSNAF system does not use barite as a weighting agent; therefore, problematic high-gravity solids sag is eliminated during static conditions or with circulation at low pump rates.

With LSNAF, high-density calcium-bromide ($CaBr_2$) brine is used to adjust fluid density accordingly. Both BARACARB® lost circulation material (LCM) – acid-soluble calcium carbonate, sized ground marble – and STEELSEAL® resilient graphite carbon-based LCM were used in a carefully engineered bridging package, specifically formulated using WellSET® lost circulation treatment to improve wellbore strength.

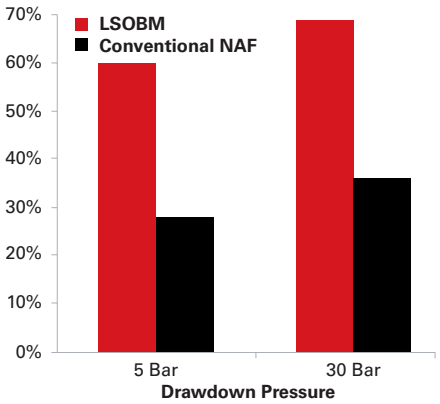
The introduction of LSNAF provided the operator with significant savings in completion design, increased well productivity and improved well life expectancy.

A fluid capable of maximizing pore throat bridging with minimal particle and filtrate invasion was tested on ceramic disks. As a base fluid for the system, Baroid engineers chose to use XP-07™ fluid, a low-kinematic, viscosity-base oil capable of delivering tight and robust emulsions suitable for HPHT conditions in the Norwegian Sea.

To complete the system, a custom surfactant package combining Halliburton emulsifiers was developed to emulsify heavy brines at high temperatures while complying with stringent North Sea environmental regulations.

For two of the multilateral wells and one through-tubing rotary drilling well, a 1.15–1.2 s.g. LSNAF system was used to drill the 8-1/2-inch, high-angle reservoir sections. The total combined footage was 34,478 feet (10,509 meters). The wells had a minimum section length of 5,604 feet (1,708 meters) and a maximum length of 9,002 feet (2,744 meters). The total solids content of the LSNAF system was primarily found in the designed bridging package containing 43 lb/bbl (123 kg/m^3) of BARACARB and STEELSEAL LCM.

Return Permeability Analysis



In a return permeability analysis, LSNAF shows a return permeability of 58 percent and 67 percent for 5-bar and 30-bar drawdown pressures, respectively, representing more than a 50 percent improvement over conventional barite-weighted fluid systems.

RESULTS

The introduction of LSNAF provided the operator with significant savings in completion design, increased well productivity and improved well life expectancy.

With the LSNAF system, formation damage was reduced, thus increasing return permeability by 50 percent when compared to conventional non-aqueous drilling fluids.

- The operator was able to change the completion by using screens in the open hole, which also offered significant savings.
- A major increase in the productivity index was realized after successful completion of the well.
- Using the LSNAF system resulted in low gel strength, translating to low viscosity and better ECD control.
- The LSNAF system eliminated the need for costly fluid displacements because it was easily converted into a completion fluid for sand-control screen placement.
- The system required low maintenance.

Preliminary results of formation skin analysis of the reservoir revealed a significant reduction in formation damage and negligible or even negative skin factor values.

Despite the extended openhole exposure time, the operator experienced very good wellbore conditions and a slick filter cake, which significantly reduced operational time and improved the running and setting of completion sand-control screens.

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