CASE STUDY

HALLIBURTON

Caspian Sea

High-performance WBF, nano sealant mitigate fluid loss, deliver wellbore stability

BaraHib® high-performance water-based fluid system with nano wellbore sealant eliminate differential sticking tendencies, enable extended logging at 5,900 psi overbalance

CHALLENGE

- Torque (after connections) increases as depth, drilling fluid weight, and solids content increases
- Fluid density up to 19 ppg-plus possible; 17-18 ppg required
- Depleted zones can result in overbalance greater than 6,000 psi
- Traditional water-based fluid (WBF) additives for filtration control contribute to high rheological properties

SOLUTION

- Combination of BaraFLC® Nano-1 wellbore sealant and non-ionic polymer form an effective seal; this leads to thin filter cakes that perform in a high solids environment

RESULTS

- Fluid loss performance on 10-μm ceramic disc, with 4,500 psi overbalance, maintained below 15 ml, with fluid densities from 12 ppg to 17.2 ppg
- Filter cake thickness did not exceed 3 mm

Halliburton studied the fluid loss and filter cake generation at high overbalance at the Caspian Sea asset. We then implemented a custom fluid system that mitigated fluid losses, minimized torque, and helped the operator drill through multiple sand layers with up to 5,900 psi overbalance and minimal sticking tendencies.

Overview

Optimal drilling performance in some Caspian Sea fields is hampered by a combination of highly depleted sands and over-pressured shales. High drilling fluid densities are needed to hold shales in place. This increase in overbalance leads to filtrate invasion and differential sticking risks in permeable zones. When sealing and bridging the sands, filter cake thickness increases with continued leakoff over time. As a result, torque multiplies while drilling through highly depleted sands. As depth and fluid weights increase, differential sticking events become common. In the most extreme cases, this trend can result in lost bottom-hole assemblies (BHAs), section redrills, and significant lost time. This increases the total cost to achieve the well objectives.

Challenge

Complex mixed formations with depletion from prior production pose multiple challenges to drilling. In many cases, oil-based muds (OBMs) are required to provide adequate shale stabilization and low filtrate invasion. Water-based fluids (WBFs) face a host of issues because high solids content is needed to achieve the required density. The filter cake deposited inside the wellbore must remain as thin as possible.

Conventional additives can achieve filtration performance on par with OBMs, but this often results in thick filter cakes and excessive fluid viscosity. Thin, impermeable filter cakes are needed to minimize the risks of differential sticking, lost time, or lost bottom-hole assemblies (BHAs).

Solution

Various micro and nano products (including traditional latex copolymers and newer, composite nanotechnology) were evaluated with traditional and nontraditional fluid loss solutions. Target sands are +/-100 mD with overbalances as high as 6,000-plus psi. Fluid loss from standard fluid formulations, consisting of many combinations of these products, was compared using the pore plugging apparatus (PPA). Test conditions were limited to a 4,500-psi differential for laboratory safety reasons and 10-µm ceramic discs. The combination of BaraFLC® Nano-1 nanotechnology wellbore sealant and a proprietary Baroid nonionic polymer proved to be the most effective at providing a thin filter cake and adequate fluid loss control. In addition, the current shale inhibitor package (amine, encapsulator, glycol, and salt concentration) was validated against retrieved field cuttings.

This study allowed for a detailed comparison of their optimum concentrations with respect to the new amines in the presence of BaraFLC® Nano-1 wellbore sealant. Filter cakes for lab formulations remained thin (comparable to OBM filter cakes) over a wide range of densities from 13 ppg to 18 ppg — even at this high overbalance pressure (Figure 1). The filter cakes quickly sealed to minimize continued leakoff and any subsequent cake growth. As an additional benefit, this was achieved without sized carbonate present, reducing the overall solids content.

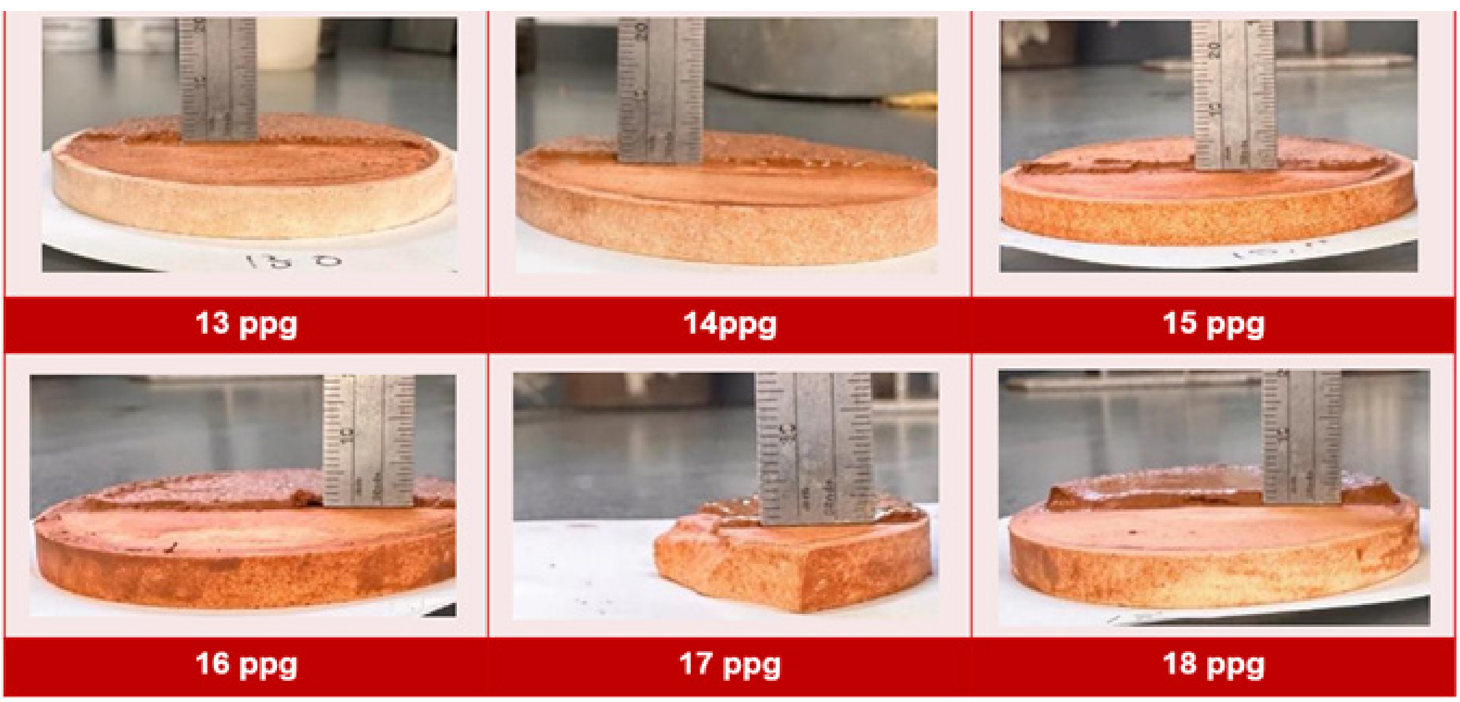
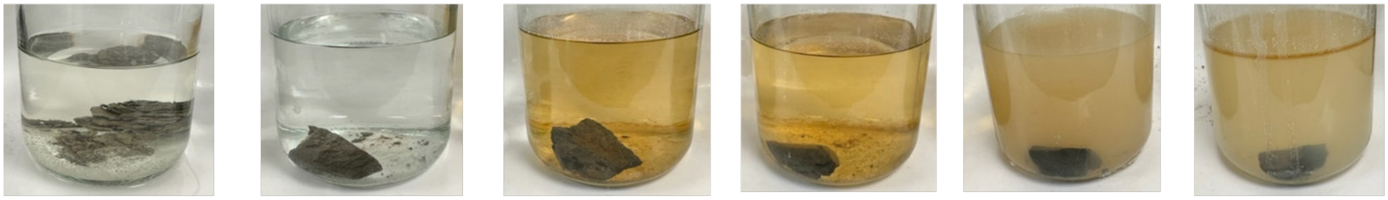


Figure 1: Lab fluids — 4,500 psi on 10 µm ceramic discs, 13 ppg up to 18 ppg. Filtrate totals ranged from 8-15 ml.



Water | +Salt | +Glycol | +Amine | +BaraHib® Nano | +Encapsulators

Figure 2: "Water to full formulation" after 72-hour bench test of shale inhibition.

Results

The implementation of the first developed BaraHib® Nano system, with a trackable inhibitor package and nanocomposite wellbore sealant, minimized and controlled fluid loss throughout the entire well. At times, the overbalance was as high as 5,900 psi (measured). However, the fluid produced a consistently thin, fast-sealing filter cake. This proactive measure prevented additional cake buildup and effectively stopped the significant increases in breakout (post-connection) torque. This was a primary causal factor for past differential sticking incidents. There were no indications of differential sticking in this well, and drilling proceeded without incident to target depth.

The graphs on the next page (Figure 4 — with the same depths and the same torque scale) show a near-vertical breakout torque profile in the 6-in. section, indicating very little increase throughout the section — even though the fluid density was increased from 15 ppg up to 17.2 ppg at target depth. The offset well on the right of Figure 4 shows the torque increasing proportionately to the depth, with the highest breakout torque of 15.7 klbs/ft. Torque on bottom increased beyond 2,500 m even with lubricant added. In contrast, the well with BaraHib® Nano (left side) produced a marginal increase in torque from top to bottom in this hole section with a maximum reading of 9 klbs/ft after a wiper trip.

Without the wiper trip, the maximum overall torque was 8 klbs/ft without the need for lubricant additions. The impressive improvement in torque readings and the extremely low friction factors allowed the operator to trip out on elevators rather than back-ream. The operator gained full confidence in the stability of the well and initiated an extensive logging program inclusive of a 31-point MDT to ascertain pore pressures and overbalance.

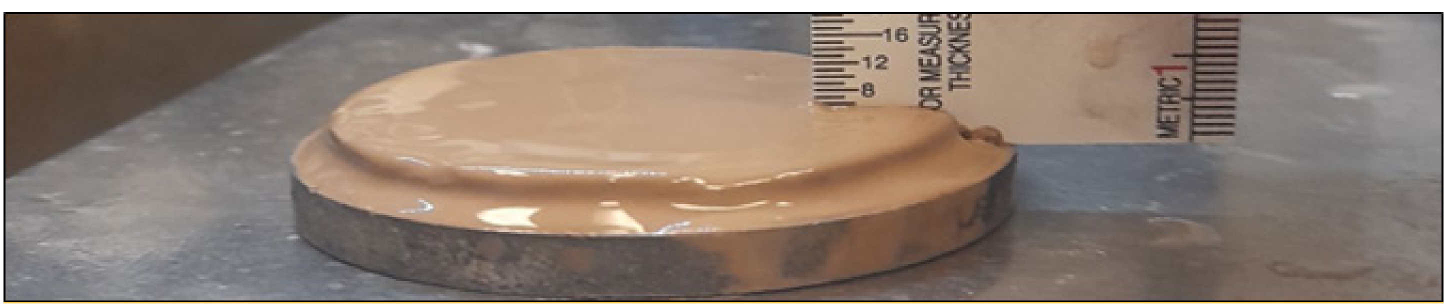


Figure 3: Field fluid: 4,500 psi on 10 µm ceramic disc, 17.2 ppg. Fluid loss = 14.6 ml (total).

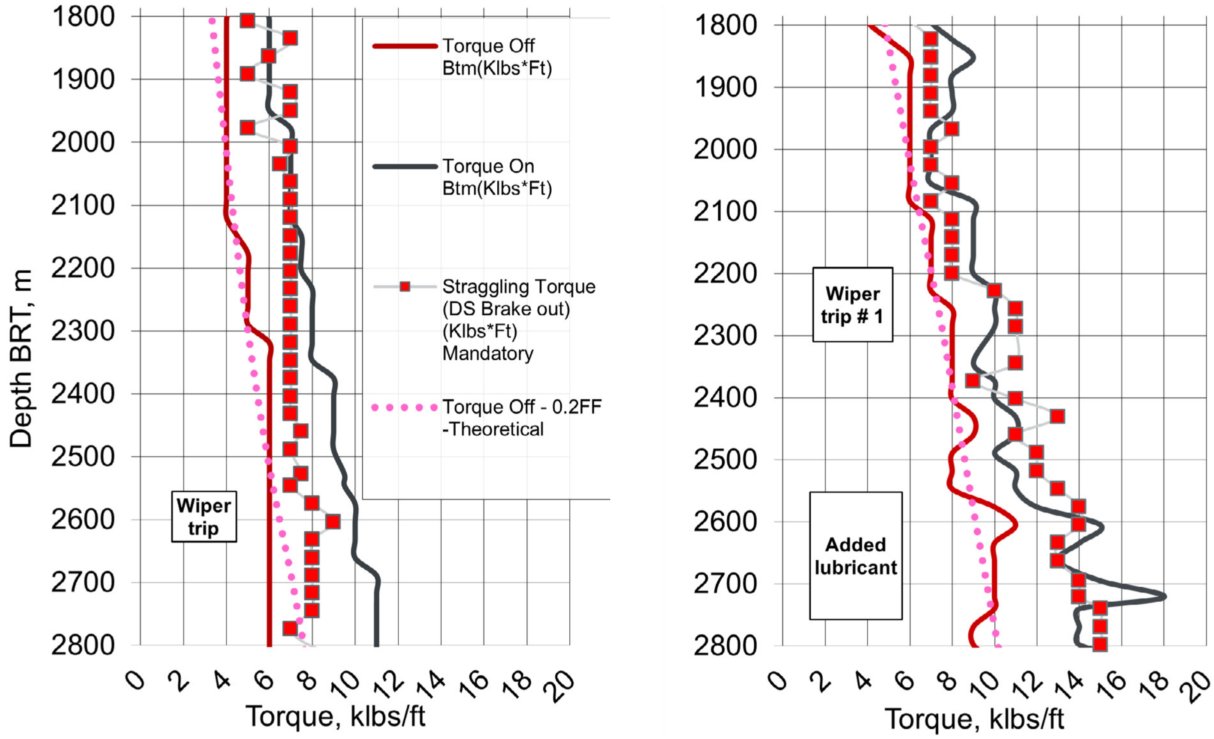


Figure 4: Target well (at left) shows a near vertical breakout torque profile compared to the offset well. The offset well on the right shows the torque increasing proportionately to the depth, with a highest breakout torque of 15.7 klbs/ft. Torque on bottom increased beyond 2,500 m even with lubricant added. In contrast, the well with BaraHib® Nano (left side) produced a marginal increase in torque from top to bottom in this hole section with a maximum reading of 9 klbs./ft. after a wiper trip.