Case History

Kronos™ CW Non-Aqueous Flat Rheology Drilling Fluid Successfully Drills Challenging Carbonate Reservoir Sections, Onshore Middle East

Newpark's expertise and customized formulation of Kronos™ CW (Critical Wells) flat rheology drilling fluid with nanoscale additives allowed the operator to drill 2 carbonate reservoir intervals safely with no NPT or fluid losses, despite extreme overbalance pressure

CHALLENGE	SOLUTION	RESULT
• Successfully drill 2 carbonate reservoir sections with overbalance pressure >5,700psi • Maintain drilling fluid flat rheology with downhole temperature range 220 - 330°F (105 – 165°C) • No barite sag	• Kronos CW™ non-aqueous flat rheology drilling fluid system with novel nanoscale additives • Continuous monitoring and supervision by experienced drilling fluids engineers	• 2 carbonate reservoir intervals safely and trouble-free • Zero NPT recorded • No fluid losses encountered • Liners run without the need for rotation or fluid circulation

OVERVIEW

Newpark Fluids Systems were invited by an operator in the Middle East to perform trials onshore with its next generation Kronos™ CW flat rheology non-aqueous drilling fluid.

Newpark developed this uniquely customizable flat rheology drilling fluid to meet rigorous performance parameters and maintain well control in a variety of challenging drilling conditions, at temperatures ranging from 220 - 330°F (105 – 165°C) downhole. The rheological 'flatness' was tested in the lab and in field in temperatures ranging from 60 - 150°F (16 – 66°C)

The fluid constituents were carefully selected to exhibit a flat rheology profile to aid in trouble-free drilling of the well. The fluid also used a novel nanoscale additive for filtration control, to enhance filter cake properties in high overbalance situations and minimize the risk of differential sticking which is a large contributor of non-productive time (NPT) in drilling operations.

During the trial, the fluid's properties were recorded across various temperatures and pressures to understand behavior at different sections of the well.

CHALLENGE

The trial required 2 reservoir intervals to be drilled in an onshore field, and the operator set strict key performance indicators (KPIs) for the Kronos CW drilling fluid as follows:

- Comply with flat rheology requirements (gel strength and yield point, with a 30% maximum variation between 60 - 150°F (16 - 66°C) temperature range)
- Successful and trouble-free drilling of the entire hole section with necessary fluid density and drilling fluid properties maintained

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- Fluid products consumption in line with the estimated product consumption plan
- No excessive dilution, no excessive mud thickening or thinning due to downhole conditions
- No solids settling ensuring proper suspension with adequate low end readings profile (Sag factor must be within 0.5 – 0.53 range)
- No significant changes to mud properties
- Low break circulation pressures.
- No issues running liner or casing to bottom related to fluid condition

Specific drilling challenges experienced in these formation types in offset wells in the area are as follows:

- High permeability carbonate reservoir formation with overbalance pressures expected at >1,500psi in the first reservoir interval and >5,700psi in the second interval
- Overpressure & water influx while drilling into shale
- Potential for shale sloughing/swelling and tight/sticky wellbore
- Possible lost circulation with a frac gradient 101 pcf, while drilling fluid at 105 pcf
- Possible for differential sticking across reservoir carbonate

SOLUTION

Kronos CW is a 2nd generation flat rheology non-aqueous fluid (FR-NAF) with specific applications in high overbalance, narrow margin well design. Flat rheology is the term used to describe NAF (Non-Aqueous Fluid) behavior that is nearly constant, and independent of temperature and pressure effects in the drilling environment. The constant rheology characteristics of FR-NAF are designed to address drilling issues (such as equivalent circulating density (ECD) management, downhole losses, hole cleaning, sag mitigation) through optimal control of fluid rheological properties in complex, narrow margin environments

The key fluid properties monitored across the temperature range vary across the industry for FR-NAF; plastic viscosity (PV), 6-rpm reading, and gel strengths are the properties mostly commonly measured and managed. The rheology evaluation criteria during this test for the Kronos CW fluid utilized API rheological properties measured through use of a 6-speed rotational viscometer.

These parameters were:

- 10 min gel < 1.7 times 10-second gel
- 30 min gel < 1.3 times 10-minute gel
- Gels at 60°F (16°C) < 30% gels at 150°F (66°C)
- PV at 60°F < 2.5 times PV at 150°F

Additionally, the flat rheological profile should be consistent across a range of temperatures (60 – 150°F, 16 – 66°C), and pressures up to 15,000 psi (1,034 bar)

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RESULTS

Results achieved against the expected challenges in the drilling program, and the KPIs set by the operator, have been summarized in the table below:

Challenges expected	Result
Comply with flat rheology requirements (gel strength and yield point with a 30% maximum variation between from 60°F to 150°F)	Δ YP while drilling always < 17% Δ Gels always < 20%
Overpressure while drilling shale	Overpressure not recorded, hold 125 pcf MW for the entire 8 3/8" interval
Water influx while drilling into shale	Not recorded
Possible shale sloughing/swelling and possibility of tight and sticky hole	Kronos CW prevented any issues
Possible lost circulation if mud weight is too high	Losses not recorded
Carbonate reservoir formation, in this well, is expected to have a high permeability and an overbalance > 5,700 psi	Kronos CW added with proper bridging package avoided any issues.
Possible lost circulation with a frac gradient 101 pcf, while drilling fluid at 105 pcf	Kept mud weight stable at 104 pcf without issues.
Possible sticking across Reservoir carbonate formation	Kronos CW added with bridging packaging and nanoparticles avoid any issues also with a differential pressure of 5,700 psi.
Successful and trouble free drilling the entire hole section provided the adequate fluid density is used	0 NPT recorded for Kronos CW 0 NPT for downhole issues
Maintained drilling fluids properties as programmed and reasonably within the estimated product consumption presented by Newpark Fluids Systems	Properties in specs and consumption reasonably in line with estimations, considering operational needs and equipment availability
Achieve and maintain flat low end rheology, gel strength and yield point with 30% maximum variation between from 60°F and 150°F when reading rheology parameters with Fann 35 / Ofite viscometers	Δ YP while drilling always < 17% Δ Gels always < 20% Δ low end reading almost always nul (0%)
No excessive dilution, no excessive problems of mud thickening up nor thinning down due to downhole conditions	No excessive dilution needed. No thickening/thinning issues experienced
No solids settling ensuring proper suspension with adequate low end readings profile (Sag factor must be within 0.5 – 0.53 range).	Sag always < 0.53 Best result achieved 0.508

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No problems during initial or maintenance mix of fluid, homogeneous mixture generated	No mixing issues, even when mixing Logging Pill with competitors' chemicals in Kronos CW
No drastic or significant changes in mud properties attributable to inadequate mixing, poor maintenance or lack of supervision	Never experienced drastic nor significant changes in mud properties
Low Break Circulation pressures.	Low Break Circulation pressures experienced also after 48 h of Logs
No issues running liner or casing to bottom related to fluid condition.	Both Liners ran without need of rotation nor circulation to bottom.

The expertise of Newpark's fluids engineers and the customized formulation of the Kronos CW drilling fluid with nanoscale additives allowed the operator to drill the 2 carbonate reservoir intervals safely and trouble-free, despite the overbalance pressure of 5,700 psi.

Zero NPT was recorded, no fluid losses were encountered, and the operator was able to run liners without the need for rotation or fluid circulation.