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Breakthrough liquid fluid loss control agent in oil-based mud improved HPHT fluid loss by 40% across extended reach wells

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Abstract

Despite extensive advancements in strategies of oil-based mud (OBM) filtration control, conventional black powder-based additive still suffers from several drawbacks. Using a liquid fluid loss control agent (FLCA) across extended reach wells improves hole conditions and optimizes cost and mixing recourses.

Several HPHT examinations were conducted to measure the effectiveness of the liquid FLCA at various temperatures in comparison to conventional solid-base FLCA. Additionally, an actual application example for this implementation explores the impacts on torque and drag (T&D), tripping smoothness, and sticking tendency while drilling across reservoirs. The study discusses the advantages and limitations related to mixing practices and associated resource management.

The liquid FLCA was directly added to the drilling fluid system without the need for special equipment. Thus, hourly treatment was reduced by 30%, which enhanced utilization of mixing resources and decreased associated cost with storage and logistic of backup chemicals. As shown from several field implementations, HPHT fluid loss was optimized by 40% and filter cake builds up across the reservoir improved to the optimum level as shown from collected data in the field.

The novel chemistry of the liquid FLCA provides many advantages, i.e., better production initiation pressures, elimination of permeability reduction due to fine solids, lower impact on the mud weight, etc. Experimental analysis and actual field implementations presented can bridge the gap in existing knowledge related to technologies of fluid loss control especially across reservoirs where high-risk of formation damage and stuck pipe play a significant role.

Introduction

Drilling of high-temperature, high-pressure (HTHP) and extended reach wells are very important for increasing production of oil and gas wells. There are a lot of challenges that usually exist while drilling such wells, including stuck pipe, poor hole cleaning, wellbore instability, and lost circulation. Improving production became more of a challenge by utilizing no-damaging drilling fluids to facilitate drilling and running completions. Accordingly drilling fluids design plays a key rule in overcoming these challenges, delivering the wells without NPT (Non Productive Time) as per prepared plans, and maximizing production by increasing pay zone exposure and eliminating reservoir damage.

Many wells drilled as multilateral oil producers across hydrocarbon reservoirs bearing high porosity and permeability have a very long length for each lateral, utilizing very low densities of OBM. It is very important to drill with a tight HTHP to have minimum filter cake thickness and consequently eliminate the tendency of differential stuck pipe and achieve smooth tripping across this high porosity and permeability formation. Usually, it is very difficult to control HTHP in a very low density of OBM with a high oil-water ratio by utilizing conventional organophilic lignite powder, especially with a very high dilution rate of base oil to control low mud weight and progressive increase due to fine colloidal solids generated while drilling across this type of reservoir.

Development of a liquid HTHP FLC agent in OBM became a must as the number of very long multilateral wells increases across HTHP formations and high porosity formations. The liquid HTHP FLC agent tolerates high temperature and high solids content in high densities, which leads to much better control on HTHP fluid loss in different environments. Also, liquid HTHP FLC eliminates risks of filtration control difficulties in OBM with a high oil-water ratio due to very low density and a very high rate of base oil dilution to achieve the desired low mud weight.

Therefore, a liquid HTHP FLC agent was proposed to the operator to reduce the NPT and enhance the operation efficiency by decreasing risks of differential stuck across very long and highly porous reservoirs. This paper will cover an application example of a field application of the liquid FLC, and highlight the field results to be a reference for the future applications in the similar reservoirs types and well designs worldwide.

Challenges and Proposed Solution

The selected mud density needed to drill three laterals was lower than water density, which required excessive base oil dilution to keep it as per the KPI, which has a challenge to maintain all the properties, especially HTHP, without excessive treatment that usually exceeds twice the initial mixing dose. An excessive treatment of powder FLC agent would be required to drill three very long laterals leading to very high product consumption taking into consideration the continuous separation of powder FLC agent on shale shakers.

Accordingly, a liquid FLC agent was proposed due to its excellent thermal stability and its high performance and efficiency in a very high oil-water ratio, which combined with low density. The product polymeric chemistry nature with a low viscosity characteristic makes it highly efficient to control HTHP. Also, the novel polymeric chemistry for the product with minimal organophilic structure was expected to enhance production more than usage of conventional powder FLC.

Experimental Evaluation

A- Lab test descriptions

A lot of lab testing was done in the client laboratories to evaluate the product and consequently approve it for a field trial after selecting the candidate well. Preparation for trial started after selection of a candidate well, which met all the above-mentioned challenges. Preparation included formulating OBM with the new FLC agent and testing this formulation in the laboratory. After extensive pilot testing with various formulations, the optimum formulation was developed to replace the powder FLC agent with a liquid FLC agent to minimize the organophilic content in OBM and significantly improve HTHP control without affecting other OBM properties (Graph-1).

B- Lab test results

The product provided very good results in the laboratory testing stage and, accordingly, a detailed technical and commercial proposal for a field trial was submitted for review and approval by the technical team. The proposal was approved with the following KPIs:

- In a fresh built OBM, the 5 ppb of liquid FLC agent should maintain an HPHT filtrate loss of less than 6 ml at 500 psi and 280 deg F
- The liquid FLC agent should exhibit no negative effects on other OBM properties
- Field trial tests should be performed in a safe manner
- The FLC agent should pass the above criteria in two wells or laterals.

Field Trial Preparation

A challenging candidate well was identified to drill three 8 ½’’ three laterals with 7,000 ft length of each lateral (Figure-1) across high-porosity hydrocarbon reservoirs. The main concerns were focused on challenges to maintain tight filtration to minimize risk of differential stuck, reduce chemicals consumption, wellbore stability, improve hole cleaning, and minimize formation damage along with increasing production. Therefore, rheological design with a low density was critical as well to achieve very good hole cleaning and ensure optimum wellbore stability and smooth tripping.

A specific drilling fluids program, including the approved formulation of OBM with liquid FLC agent, was submitted to tackle all the operations risks and challenges.

Filed Trial Evaluation

The oil-base mud parameters for all the samples tested are shown in Table 1. The fluid loss shows a minimum 25% reduction compared to the conventional powder FLC agents. Hence, minimal filter cake thickness was observed. Also, these results were verified and confirmed by the whole technical team after checking all these results in the lab.

The filtration results for all the different samples tested are shown in Table 1. The values of the 30 min fluid loss for the conventional FLC agents range from 5.5 to 7 ml values whereas it was observed that the 30 min fluid loss values of the liquid FLC are all below 4 ml values.

Field Trial Results

The field trial contributed successfully to deliver the well without NPT and smooth tripping and successfully execute operation by providing very tight HTHP and good/thin filter cake quality (Table 1). In addition, several significant technical and financial benefits were achieved, including:

- Tight HTHP along with very thin filter cake with heavy base oil dilution.
- There is no NPT related to stuck pipe or lost circulation.
- Avoid differential stuck despite facing of downhole losses across high porosity formation.
- Hole condition was good during tripping and completion smoothly ran to bottom.
- Drilled directionally to TD at MD 17,237 ft/ TVD 6810 ft on one run of directional BHA.
- Wiper trip was canceled due to good hole condition
- 20% reduction in the base oil dilution were achieved
- 35% consumption saving of FLC agent in the three laterals.

Conclusion

Field trials successfully achieved the desired KPIs and tackled all operational risks in the extended reached horizontal wells, which included stuck pipe, poor hole cleaning, wellbore instability, and lost circulation. The proposed solution to replace the powder FLC agents with the liquid FLC agent was executed fruitfully. Technical teams were involved in optimizing formulation, pilot testing, and simulations, and then selected the candidate well based on agreed KPIs. Finally, the trial was successful and led to the following outcomes:

- Achieved all pre-agreed KPIs.
- A minimum of 25% reduction in HTHP Fluid Loss KPI was achieved on the field trial.
- Controlled LGS % to optimize ECD trends, rheology profile.
- Controlled solids content at the minimum to keep the mud density as per KPI.
- A 20% reduction in the diesel dilution was achieved
- 35% of consumption was saved for FLC agent in the three laterals.

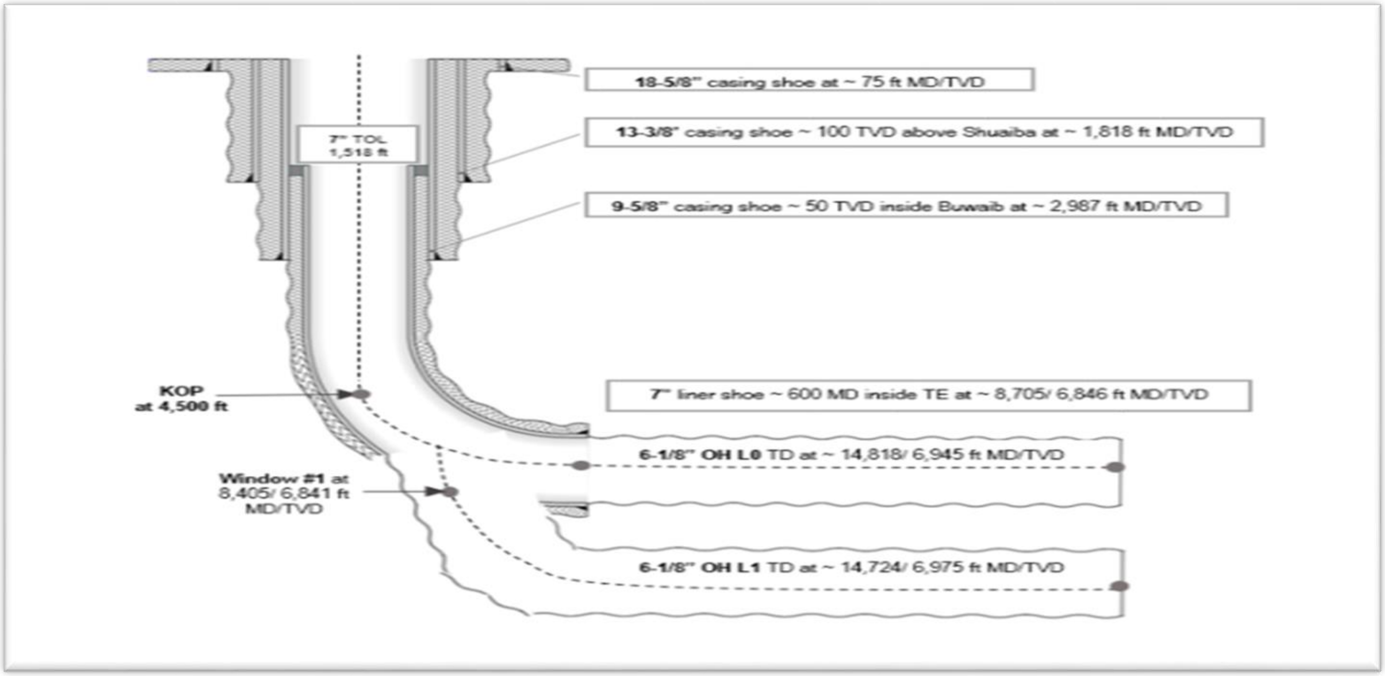
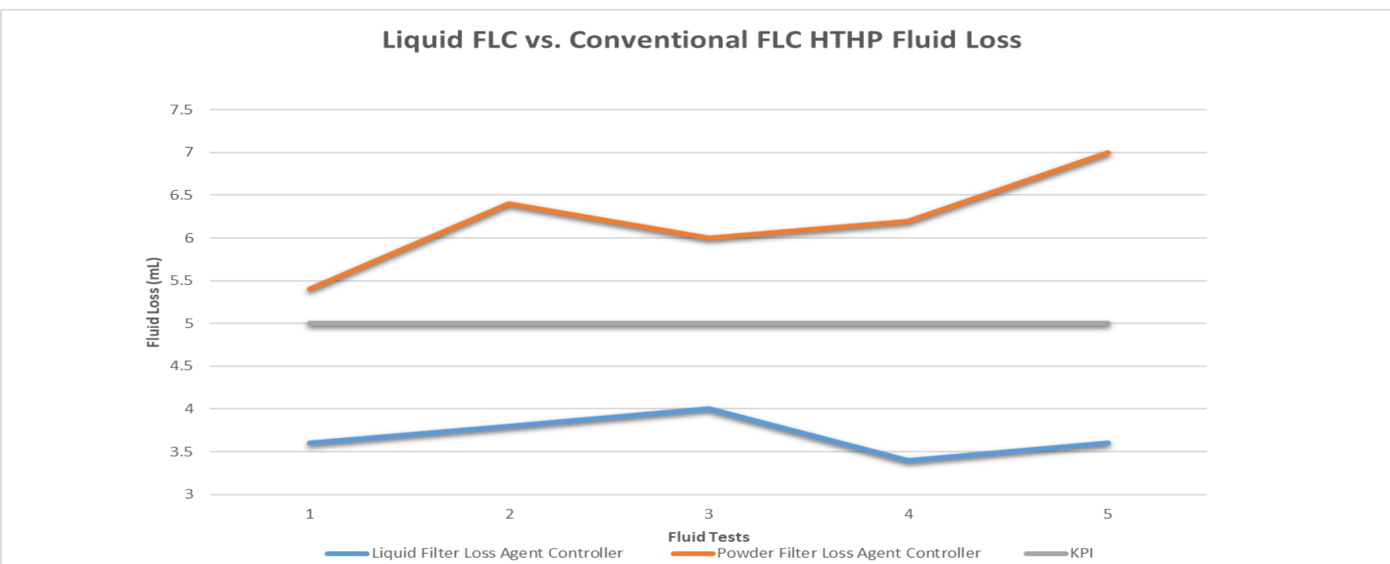


Figure 1 – Well sketch design



Graph-1 – Lab test results for comparison HTHP filtrate between Liquid FLC vs. Conventional powder FLC (organophilic)

YP	10.0-16	11	14	15
6 RPM	9.0-11	9	9	10
10" Gels	6.0-11	8	9	10
10' Gels	10-20	11	12	13
HPHT ml/30 min	< 6 @ 280 F	3.8	4	3.8
ES	> 400	1000	1100	1300
Conc. (PPB)	< 5	4.24	4.41	4.38
Test time		05:00	05:00	17:00
Comments		From Flow line at depth 14300 ft	From Flow line at depth 16070 ft	Flow line at depth 17100 ft Bttm's up of Final Circulation
Pic of filtrate and cake				

Table 1 - The daily field lab records of HTHP filtrate, rheology profile, emulsion stability (ES) and product concentration in ppb.