



Achieving the Drilling Performance Benefits of A Clay-Free System in a Variety of Commonly-used Base Fluids

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Abstract

A Clay-free system for non-aqueous phase (NAP) drilling fluids was initially developed in connection with a blended ester/internal olefin (IO) based fluid. The clay-free system has now been successfully adapted for use in other common base fluids such as IO (unblended), linear alpha olefin (LAO), and n-paraffin.

The key to the clay-free system is the replacement of traditional organophilic clay, used for rheology, and organophilic lignite, used for fluid loss, with additives based on novel surfactant and polymer chemistry. Using these products can remove the need for adding all commercial solids, with the exception of weighting agents such as barite or calcium carbonate.

The clay-free system has demonstrated unique drilling performance benefits in over 200 deepwater and shelf locations worldwide. Documented performance benchmarks include the following:

- Easily broken (fragile) gel strengths and lower equivalent circulating densities (ECD), which significantly reduce downhole mud losses
- Improved rheological responsiveness and suspension characteristics over the wide temperature ranges encountered in deepwater and high-pressure high-temperature (HPHT) applications
- Increased tolerance to contamination
- Fewer products and less inventory required compared with conventional NAP fluids.

The reduction of downhole losses while drilling, running casing and cementing, a signature benefit of the clay-free system, has helped operators minimize non-productive time and lower overall well construction costs.

Introduction

Oil-based fluids (OBF) and synthetic-based fluids (SBF), collectively called non-aqueous phase (NAP) fluids, traditionally have been formulated with common groups of components. Since the wide spread use of

organophilic clay began in the early 1960s, this technology has not been replaced primarily because of its relatively low cost and perceived effectiveness. At the time of its introduction, organophilic clay was stable at the well temperatures typically encountered¹. However, this was before drilling practices and well conditions increased in complexity and drilling fluid technologies evolved to meet these more challenging demands. These changes include:

- Drilling and wellbore conditions
 - HPHT
 - Deepwater locations and associated temperature extremes
 - Increased deviation and tortuosity
- Advances in fluid technology and testing capabilities
 - Downhole rheology simulation and prediction
 - Pressure while drilling (PWD) data
 - Static and dynamic barite sag testing
 - Accurate hydraulics modeling.

An evolving drilling environment, expanded understanding of drilling fluids, increased testing capabilities and innovations in chemistry helped pioneer a new drilling fluid system that no longer depended on organophilic clay. The clay-free SBF was first tested in the Gulf of Mexico (GOM), using an ester and IO blend as the base fluid. The new system exhibited unique performance characteristics, which have been sustained on subsequent successful wells drilled with the clay-free fluid since that time:

- Greatly reduced whole mud losses
- Exhibited the lowest ECD
- Revealed high, flat, yet easily broken (fragile) gel strengths
- Eliminated costly remediation associated with barite sag
- Increased rate of penetration (ROP)
- Used less product (due to much lower loss volumes, less dilution, lower external phase and less overtreatment).

Experience: Over 200 Deepwater and Shelf Wells

A technology so radically different was slow to be adopted at first. By the end of 2001 only three operators² were using the system. However, by the end of 2005, 20 operators had used the system on over 200 wells, and drilled over 2 million feet with the clay-free fluid. In 2005, operators began using this technology with alternate base oils such as IO (unblended), linear alpha olefin (LAO), and n-paraffin and have successfully drilled in excess of 115,000 ft (**Figure 1**).

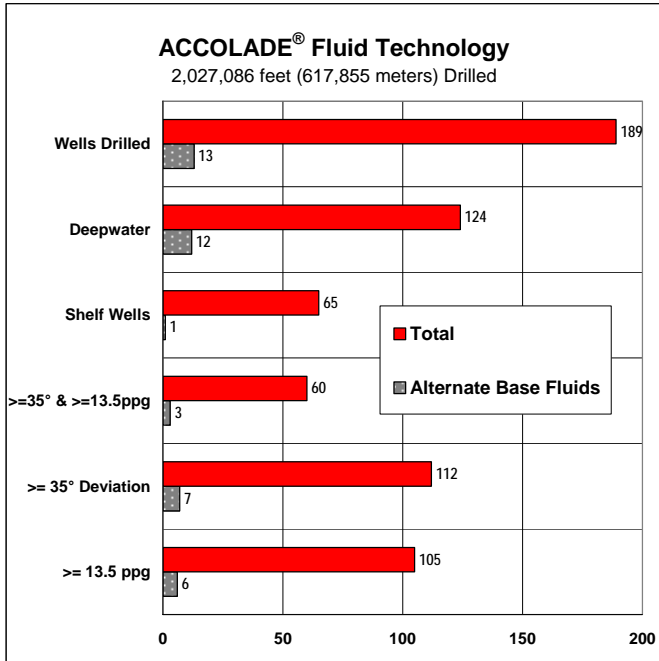


Figure 1

Performance Benefits

After successful field trials in the GOM, both operators and system developers realized that the technology provided more benefits than initially anticipated.

Temperature stability. First, removing the quaternary amine found on organophilic clay and organophilic lignite helped create a more stable rheological profile over a broad temperature range. This eliminated the occurrence of excessively thick fluid at cold temperatures, as seen in the riser, and prevented the fluid from becoming too thin at the higher downhole temperatures.

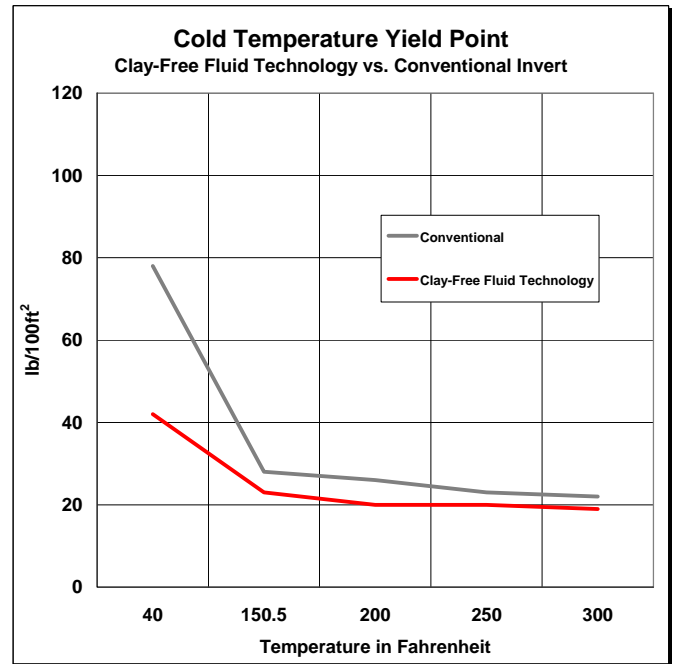


Figure 2

Figure 2 shows how dramatically the yield point can be affected by using organophilic clay and organophilic lignite. The removal of these components was a critical factor in meeting deepwater challenges.

Return permeability. The new systems also exhibited excellent return permeability results. Conventional invert emulsion fluids typically are optimized with bridging agents to prevent damage on a return permeameter. The clay-free technology outperformed many optimized and non-optimized fluids (**Figure 3**). In most tests, formation damage is confined to the 0-5% range, with liftoff pressures generally below 2 psi.

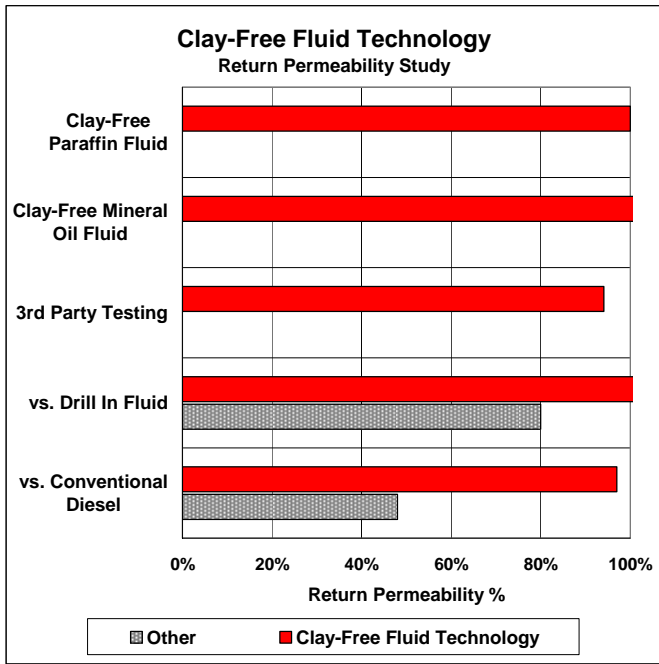


Figure 3

This results in part from the low colloidal content of the fluid and the reduction in filtercake thickness. Clay-free technology provides an extremely thin yet lubricious filter cake. As shown in **Figure 4** below, after a particle plugging test on a 35-micron aloxite disk, run at a 600 psi differential at 200°F, the new system yielded a 0.33 mm thick filter cake. An acceptable filter cake for a conventional SBF is usually around 1.6 mm thick. As demonstrated by inspections using a scanning electron microscope (SEM) on similar disks, we have found virtually no fluid invasion. This helps promote superior logging performance.

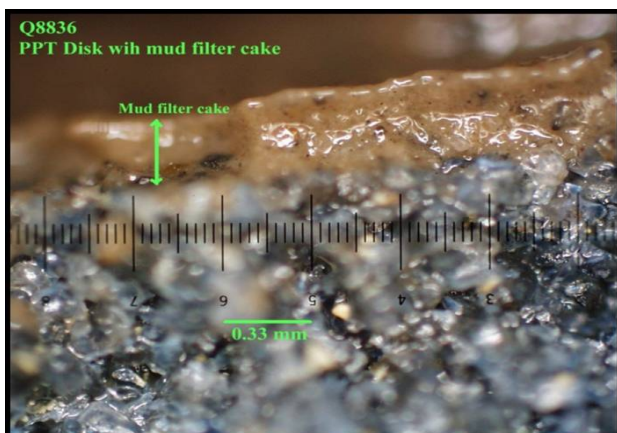


Figure 4

Suspension characteristics. Using a co-polymer and emulsification type suspension provides clay-free technology with a unique gel structure. The clay-free fluid technology exhibits unique behavior at low shear

rates. Low shear rate testing proved that the clay-free fluid rapidly builds a higher gel strength, yet breaks easily (**Figure 5**).

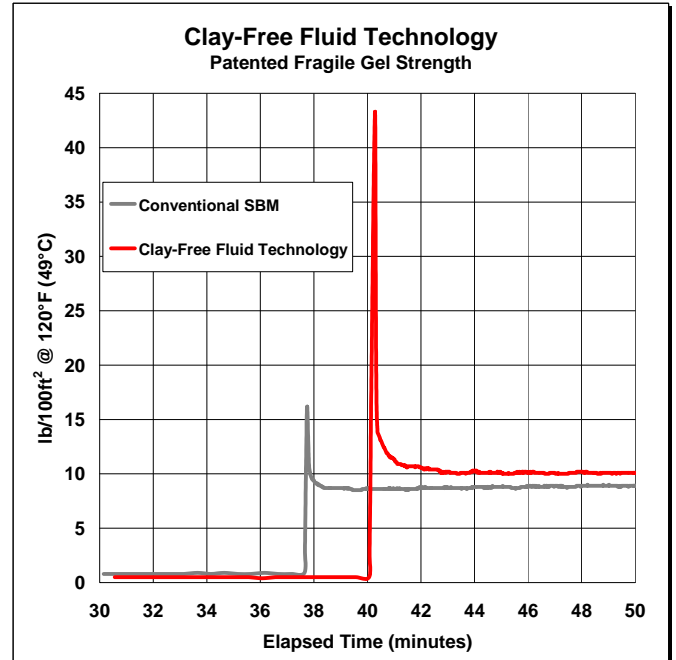


Figure 5

Reduced mud losses. This unique fragile gel strength locks in the solids at low shear rates, preventing barite sag, yet easily breaks with minimal disturbance. When initiating circulation, the clay-free system requires significantly lower pump pressures at surface than are needed with a conventional invert emulsion fluid. The fragile gel strength of the clay-free system helps provide one of the technology's most important benefits – reduced downhole mud losses. In a study of 107 wells, we have seen an average of 41% lower losses. Unlike many SBFs on the market, the unique clay-free fluid does not require that the drill pipe be rotated prior to starting the pumps to reduce the pressure spikes.

Less inventory, fewer HSE risks. By changing the chemicals needed to create formulate and maintain this unique invert emulsion fluid and by reducing downhole losses, product usage at the rigsite can be dramatically decreased. As a result of tracking products used, we found that as many as three crane lifts per 1000 ft drilled could be eliminated. This can help reduce health and safety risks on location.

PWD values. The ability to reduce downhole losses is accompanied by very specific fluid properties. The system is generally run with the same to slightly higher yield points and tau zero values when compared with a conventional invert emulsion system. However, despite these slightly higher values, the system produces

equivalent or even lower PWD values in the field.

Figure 6 shows three offsets and their corresponding PWD values. Two of the wells were drilled with a conventional invert, and one was drilled with the clay-free fluid technology.

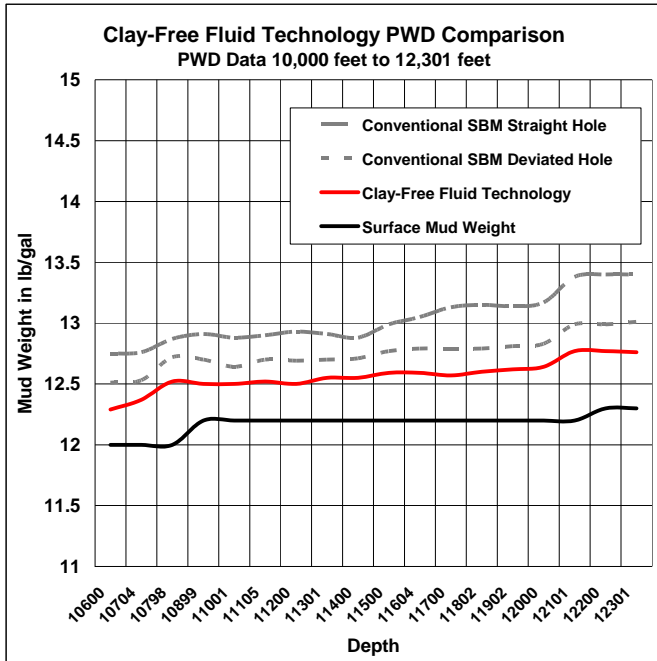


Figure 6

Expanding to Other Base Fluids

After documenting these benefits with the original formulation, the developers dedicated resources to adapting the technology into other base fluids besides the original ester and IO blend. After testing many blends and base fluids, it was found that the original chemical package could be used in the lower kinematic viscosity base fluids with minimal change to the properties and performance benefits. Depending on the kinematic viscosity of the fluid, the oil-to-water ratio (OWR) is modified to achieve the desired results. **Figure 7** demonstrates how changing the OWR affects the yield point in other, thinner base fluids.

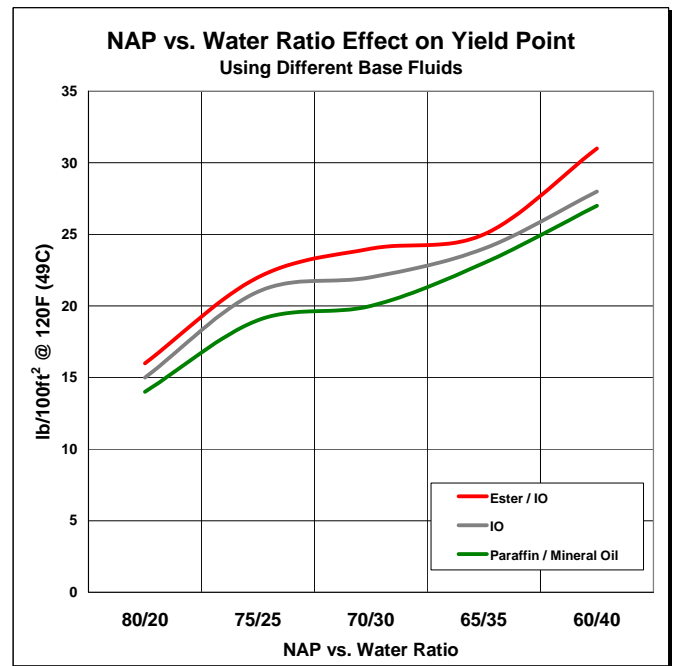


Figure 7

Changing the OWR has allowed the system to be successfully adapted in the field to all-IO and paraffin fluids, and it has been tested in the lab using many mineral oils. The benefits of the original technology have been consistently preserved in this variety of base fluids.

To date, downhole losses observed while using alternate base fluids have been even less than anticipated, with a 56% average reduction compared to conventional invert emulsion fluids (**Figure 8**).

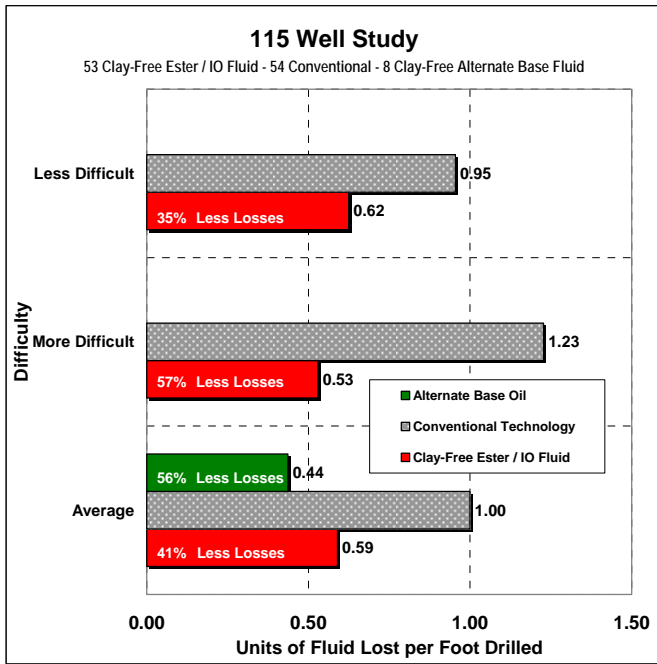


Figure 8

The removal of ester from the formulation has also resulted in an increase in high-temperature stability. By utilizing an all-IO, mineral oil, or paraffin-based fluid, we can extend the technology into the 450°F (232°C) to 500°F (260°C) range.

Conclusions

- The clay-free SBF technology can be adapted for use in a variety of cost-effective and widely available base fluids.
- The technology has been used successfully in the field with all-IO and paraffin-based fluids on 12+ deepwater wells.
- The technology has been tested successfully with mineral oil-based fluids in the laboratory and should be ready for field trials in 2006.
- The signature performance benefits of the clay-free system have been maintained in all base fluids tested in the field and in the laboratory.

Acknowledgments

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