High performance water-base fluids improve drilling

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WHEN DRILLING CHALLENGING wells, operators are always in search of a drilling fluid that delivers a stable wellbore, fast penetration rates, high tolerance for contaminants, effective inhibition and excellent lubricity. Until recently the answer to these issues has been an invert emulsion system.

Today, some high-performance water-base fluids (HPWBF) are proving their worth as cost-effective alternatives to oil- and synthetic-base systems in both performance and environmental arenas.

Used successfully on over 175 wells worldwide in the last two years, the HYDRO-GUARD®, PerformaDril® and award-winning BOREMAX™ water-base systems provide the invert emulsion performance that operators have long sought both offshore and on land. The key to a successful application using these fit-for-purpose systems is adherence to strict criteria in fluid design and formulation.

HIGH-PERFORMANCE FLUIDS

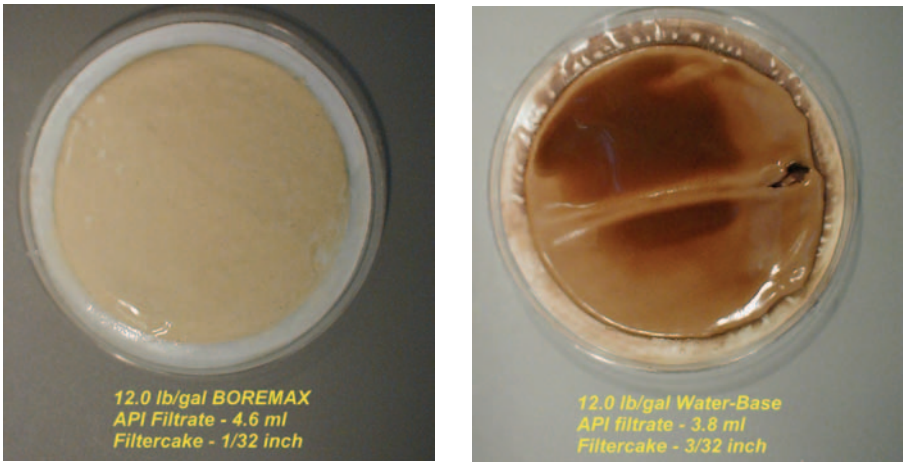
Not all so-called high-performance WBFs meet the exacting standards needed to deliver the equivalent of invert emulsion results. A true high-performance fluid fulfills all, not just some, of the four requirements listed below. These characteristics work together to effect maximum drilling performance:

- Low colloidal content;
- Effective inhibition;
- Shear-thinning behavior;
- Non-dispersed system.

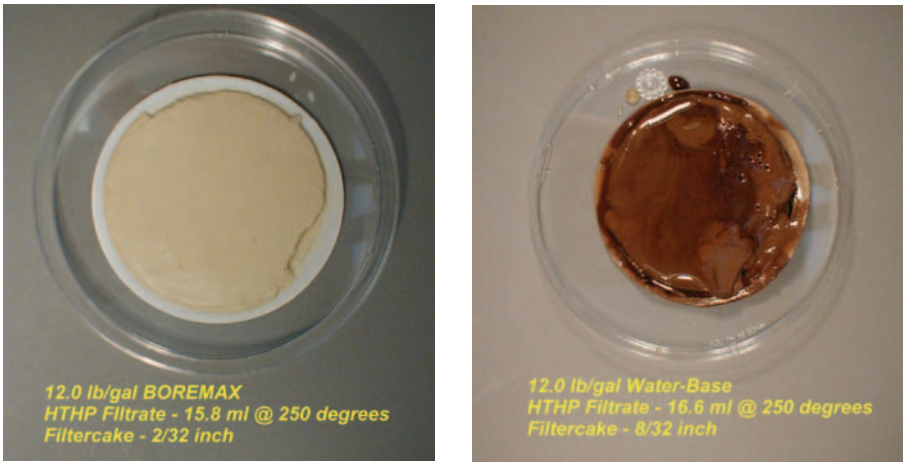
LOW COLLOIDAL CONTENT

Studies have shown that the lower the colloidal solids content in a water-base system, the faster the rate of penetration (ROP). Minimizing colloidal solids helps lower the plastic viscosity of the fluid, contributing to greater horsepower at the bit. However, removing colloidal solids becomes difficult, if not impossible, if they are allowed to accumulate and further degrade in the active system.

A true HPWBF should provide a means to chemically flocculate and encapsulate these particles so that they can be stripped out at the surface by the solids control equipment. CLAY GRABBER® polymeric encapsulator and flocculant, a field-friendly liquid additive developed through extensive work with molecular modeling, helps prevent the dispersion and disintegration that typically affects drill cuttings. This new designer polymer actually encapsulates and flocs colloidal solids to help ensure they reach the surface and are large enough to be removed by conventional solids control equipment.



A comparison of API fluid loss between high performance water-base fluid and dispersed water-base fluid.



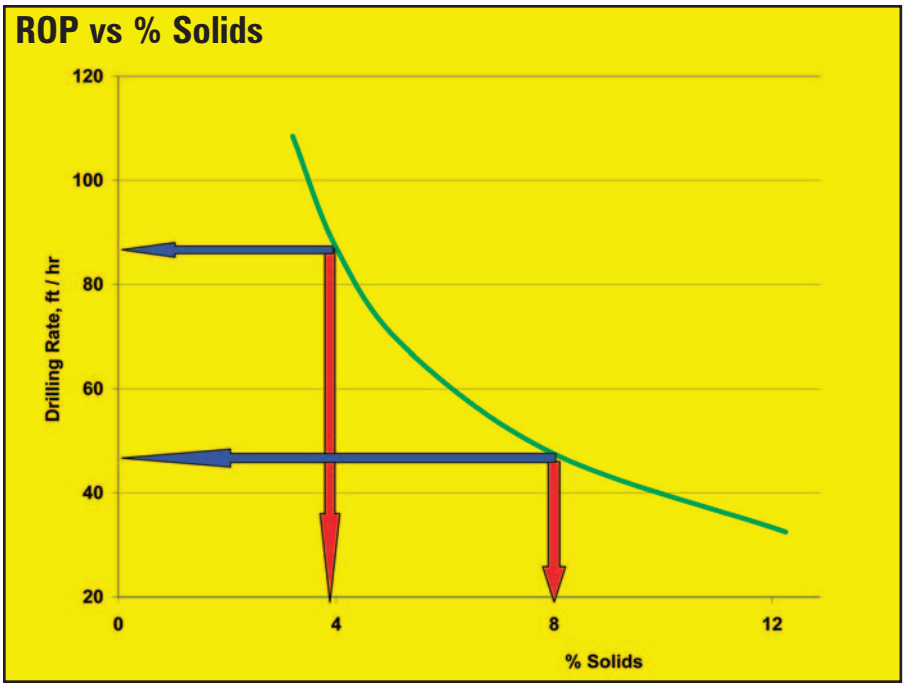
This series of photographs illustrates a comparison of HPHT fluid loss results between high performance water-base fluids and dispersed water-base fluid.

In southwest Wyoming, a six-well series provided an opportunity to compare the BOREMAX system used on three wells to the conventional dispersed WBF used on the other three wells. The wells were nearly identical: the average total depth (TD) was 14,500 ft and the comparison interval was the 8 ½-in. hole from 8,800 ft to TD. The three wells drilled with the 16.0-16.5 ppg BOREMAX system used 11 fewer bits overall, required 31 fewer days to drill and helped save $286,000 in drilling fluid costs alone.

SHALE INHIBITION

WBF that is designed only to inhibit formation clays may not go the extra step of flocculating and encapsulating the ultrafine solids that cause most of the slow penetration rates associated with WBFs. A HPWBF should both inhibit the reactive clay and facilitate removal of drilled solids over the duration of the operation. Sometimes the best test of drilling fluid performance is a long period where no drilling takes place at all.

For example, a 12.5 ppg HYDRO-GUARD saltwater system was used to drill the 12 ¼-in. interval on a deepwater well with an S-shaped build to 26°, then a drop back to vertical. Just as the operator was preparing to run the long string, Hurricane Ivan forced evacuation. The 4,000 ft



The graph illustrates the effect of the solids content rate of penetration.

open hole section was re-entered 32 days later. After only one trip to condition mud and circulate bottom up, the operator ran production pipe to bottom and cemented with no problem.

Drilling a gauge hole can allow for better quality logging data and can help improve the quality of the cement job. In turn, a good cement job contributes to successful leak-off and formation integrity tests. The HPWBFs are designed to deliver a gauge hole and help form a barrier that protects the shale matrix from water invasion.

Extensive testing with actual core samples has resulted in a well-established mineralogy reference that provides guidance in the design, formulation and application of each type of HPWBF. Each system is designed for the expected geological formations.

In a comparison between wells drilled in Lavaca County, Texas by the same operator, the caliper logs showed a hole enlargement of 9.6% for the HPWBF system, while the well drilled with a diesel-base invert emulsion system showed 7.1% enlargement. This equates to less than one-third of one inch difference between the two intervals.

SHEAR-THINNING BEHAVIOR

One of the key factors that contributes to drilling performance is the shear-thinning behavior exhibited by the HPWBFs, which have zero or very low bentonite content. An ideal drilling fluid will become thinner with increased shear. The HPWBFs become thin at the bit, maximizing hydraulic horsepower, then thicken in the annulus to provide good hole cleaning and the suspension properties necessary to support mud weights up to 17.5 ppg, at temperatures up to 375°.

An average hydraulic horsepower at the bit of 3.43 HP/in^2 was achieved with the freshwater BOREMAX system on the Lavaca County well mentioned above.

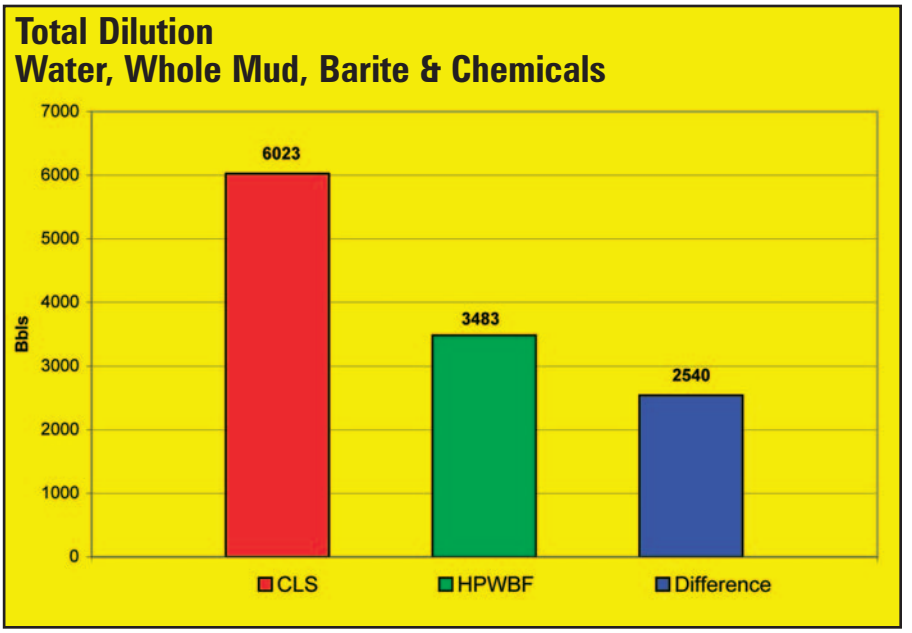
NON-DISPERSED SYSTEM

The industry has run dispersed water-base fluids for decades because dispersants help manage the rheological properties. However, the use of dispersants also sets up a "tail-chasing" scenario: drill solids are dispersed by adding chemicals, leading to the generation of ultra-fine solids, leading to an undesirable increase in rheological properties, leading to more additions of chemical dispersants and water.

Solids removal efficiency, critical to achieving a fast ROP, drops drastically as the colloidal solids build up in the system. The strongly inhibitive, flocculating and highly shear-thinning nature of the HPWBFs eliminates the need for dispersants and puts an end to the cycle of solids contamination.

An additional benefit shows up in the type of filter cake formed with these HPWBFs (Figures 2-3). The cake is built with lubricious hydrated polymers instead of being laden with ultra-fine drill solids, helping to decrease torque and drag while providing excellent fluid loss control.

Commercial sized particulate material is added to the HPWBF as needed to enhance the sealing effect when drilling permeable sections.



The graph shows the comparison of total dilution requirements between high performance water-base fluids and dispersed water-base fluids.