Synthetic-based fluid with constant rheology reduces downhole losses in deepwater operations

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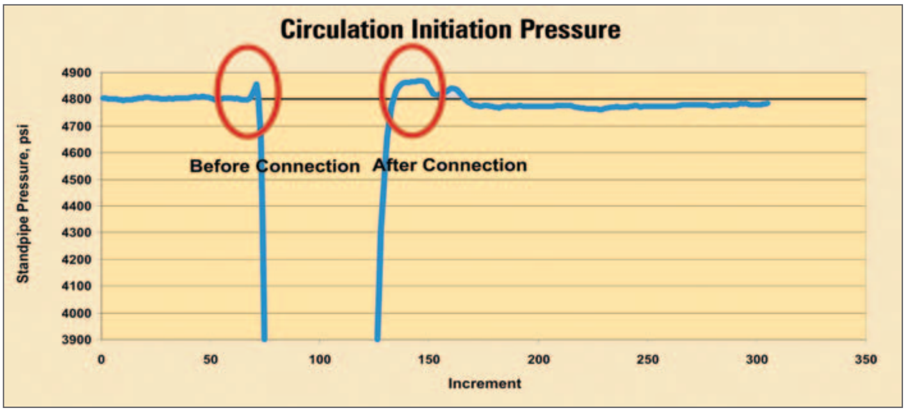
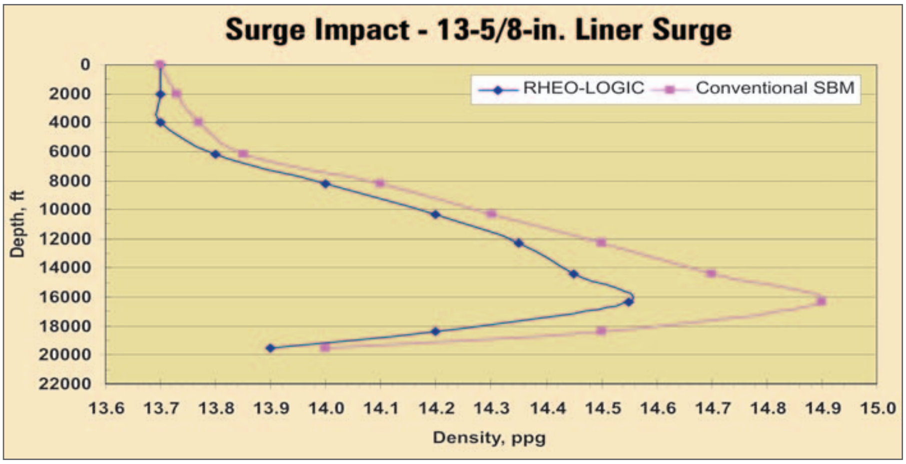
THE PREFERRED METHOD of managing pressure fluctuations in conventional SBM is to control the temperature and pressure dependency of SBM (synthetic-based muds) viscosity and gel strengths. A new SBM, exhibiting a constant rheological profile over a broad range of temperatures and pressures, has recently been developed specifically for deepwater operations. Unlike conventional SBM, the fluid exhibits a "constant rheology" profile under the temperature and pressure conditions encountered in deepwater operations. With its constant rheological and gel strength profiles, surge pressures and ECDs are minimized in the wellbore, reducing the frequency and severity of lost-circulation events. The innovative SBM is fully compliant with Gulf of Mexico environmental requirements for cuttings discharge.

SBM have long been the preferred drilling fluid for deepwater operations due to their ability to deliver well objectives while minimizing risk and costs. Key benefits derived from use of SBM include gas hydrate suppression, high rates of penetration (ROP), wellbore stability, and torque and drag reduction, resulting in lower overall well costs. The status quo of using conventional SBM would remain in place were it not for the frequent and recurring problems of downhole losses associated with SBM.

The margin between fracture gradient and pore pressure are typically narrow in deepwater operations, particularly in the Gulf of Mexico (GOM). The temperature dependency and resulting pressure increases arising from conventional SBM often exceed this pressure window, resulting in a lost-circulation event. Losses of SBM during wellbore construction often occur when drilling, tripping, running pipe and cementing. Drilling losses are usually related to the equivalent circulating density (ECD) exceeding the fracture gradient. Tripping and cementing losses are related to surge pressures arising from SBM gel structure and the equivalent static density at the time of the operation.



Above: With its constant, low-energy gel structure, pressure spikes associated with initiating circulation are virtually eliminated with the RHEO-LOGIC system. Below: Surge pressures when running casing with the RHEO-LOGIC system are reduced when compared with conventional SBM, resulting in minimized downhole mud losses.



Downhole temperatures and pressures encountered in deepwater operations create a unique challenge in managing static and dynamic pressures. Temperatures encountered in deepwater operations decrease dramatically from the surface to the mud line, where temperatures can decrease from ambient to 40° F (4° C) at water depths of 2,000 ft. This temperature reduction across the length of the riser effectively cools the drilling fluid, raising its viscosity, resulting in increased downhole pressures and lost-circulation potential. This potential for losses is increased with conventional SBM when the mud column has been static and the temperature profile has reverted close to the geothermal gradient.

Initial development work was carried out on a fluid with a density of 12.0 lb/gal using an internal olefin as the base. An olefin base fluid was selected in lieu of other available base fluids, particularly esters, with consideration to product compatibility, environmental acceptance, kinematic viscosity and temperature stability. The system was engineered in such a way that the same emulsifier package found in the conventional SBM was also compatible with the CR-SBM. This was a tremendous breakthrough in that the majority of components found in conventional SBM were compatible with the CR-SBM, with exceptions being those of the viscosifier package.

The importance of organophilic clay in managing dynamic barite sag is well documented; therefore, it was important that a high-quality organophilic clay was used in the viscosifier package. This novel organophilic clay, new to the GOM deepwater arena, was the first step in achieving a constant rheology profile, at levels sufficient to deliver performance for hole cleaning and barite sag. Barite sag is the density variation observed in directional wells observed when circulating bottoms up after operations where the drilling fluid has been exposed to near static conditions. A significant amount of work has been undertaken to investigate and understand the mechanisms of dynamic barite sag and to provide direct and indirect well-site tests to manage the problem. It is well understood that appropriate control of low shear rate viscosity is fundamental to managing the problem and that organophilic clays are the most effective viscosity control additives to manage the problem.

A second key in development was the identification of a polymeric viscosifier specifically designed to perform synergistically with the organophilic clay. Having established the compatibility of the other constituents of the system with the new viscosifier package, a rigorous program of optimizing the product mix and concentrations was initiated. This testing was conducted over a range of densities expected to be encountered in deepwater operations, ranging from 9.7 lb/gal to upwards to 12.0 lb/gal.

The most recent generation of CR-SBM is unique in the sense that a near-constant profile of these key rheological properties was achieved while using organophilic clay, but without the use of special emulsifiers and wetting agents. It is a straightforward system in that a constant rheological profile has been achieved using the same base fluid and emulsifier package found in conventional SBM. Other CR-SBMs utilize different emulsifiers, wetting agents and rheology modifiers, making them more complex and expensive to maintain.

The new CR-SBM has been used in a series of deepwater applications in the Gulf of Mexico. Each well was in progressively deeper water, with increasingly challenging drilling parameters. The desired objectives included:

• Maintenance of environmental compliance for Gulf of Mexico discharge.

• Reduction in pressure spikes when initiating circulation after connections and trips.

• Reduction in surge pressures when running casing to eliminate or reduce whole mud losses compared to similar offsets.

• Elimination of mud-related non-productive time (NPT)

Two parameters that confirm the value of the CR-SBM are a reduction in downhole losses, resulting in reduced mud-related NPT, and increased operational efficiency. Pre-drill hydraulics modeling was performed comparing the CR-SBM to a conventional SBM. The simulations were set up to compare conventional SBM to the new CR-SBM with respect to ECD, SPP, pressure spikes and tripping speeds. The only variables in these cases were the HPHT viscosity readings of the SBM and CR-SBM being evaluated. This type of analysis provided for side-by-side comparison of the results. The modeling indicated that when running casing, surge pressures could be reduced through use of the CR-SBM. The reduction in surge pressures would reduce the potential for mud losses when tripping pipe or running casing. Field experience with the system confirms the accuracy of the surge pressure modeling, having resulted in a significant reduction in downhole losses, especially when running casing.

Operational efficiencies have also been increased with use of the CR-SBM, although it is more difficult to measure the actual value without benchmarking specific operations. The daily cost associated with drilling in deepwater can easily exceed $500,000/day. Therefore incremental cost savings realized during drilling could be significant when operations — such as the time it takes to make connections and resume drilling, and trip times associated with bits, downhole tools and casing — are considered. Due to the fluid's low-energy gel structure, faster trip speeds and lower pressure spikes when breaking circulation have been realized. Pressure management benefits of the system allowed the drilling team to trip to bottom, eliminating the need to stage-in the hole, thereby reducing NPT and rig-related costs. With use of the CR-SBM, no mud-related NPT has been recorded.

Field data clearly show that the benefits derived from the CR-SBM include:

- Reduced surge pressures.
- Reduced circulating pressure (ECD).
- Reduced circulation initiation pressures.
- Reduction in downhole mud losses.
- Optimized hole cleaning.
- Improved barite sag management.
- Control of wellbore breathing (ballooning).
- Reduced non-productive time.

CONCLUSIONS

- A new family of CR-SBM has been developed to reduce downhole losses of SBM.
- CR-SBM exhibit near constant rheological properties, primarily gel strengths, yield point and 6/3 rpm readings and are not significantly affected by temperature and pressure.
- CR-SBM can be formulated using many of the components currently available in conventional SBM, differing primarily in the viscosifying package.
- Benefits of CR-SBM include reduced dynamic and static pressures, leading to the reduction in downhole mud losses when drilling, running casing and cementing.
- Additional benefits from use of CR-SBM include reduction in mud-related NPT and well costs.

This article is based on a presentation at the 2007 AADE National Technical Conference and Exhibition on 10-12 April in Houston, Texas.