Flat rheology SBM shows promise in deepwater

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A NEWLY ENGINEERED synthetic-base drilling fluid, that unlike conventional invert emulsion systems exhibits a consistently flat rheology even in the deepwater environment, has demonstrated promising performance characteristics in field trials in the deepwater Gulf of Mexico.

Owing to its balanced yield point, which translates into efficient hole cleaning across a broad spectrum of downhole temperatures, the new system delivered average rates of penetration (ROP) some 30 ft/hr higher than the conventional synthetic-base drilling fluids employed in offset wells. In its initial trial, the system drilled a 17 ½-in. section at ROPs as high as 150 ft/hr with zero losses. The system also exhibited excellent displacement, low dilution rates, and reduced requirements for chemical treatment. In addition, equivalent circulating densities (ECD) values were less than offset wells.

The system represents a new generation in synthetic-base drilling fluid technology by providing rheology properties, especially yield point, low shear rates and gel strengths, that are independent of temperature. This provides a clear indication of how the mud system will function over a wide range of temperatures, including seafloor, bottom-hole circulating and flow-line temperatures. The major technical benefit of the new system is that while surface rheology numbers may at first appear higher than usual, the flat rheology profile allows the fluid to deliver consistent downhole rheology parameters.

Engineered with lower clay content and employing newly developed emulsifiers, rheology modifiers and viscosifiers, the system was designed to address issues specific with drilling deepwater wells using synthetic-base drilling fluids. In deepwater, the cold temperatures in the riser elevate the viscosities and gel strengths of most standard invert emulsion drilling fluids. Further, operations such as tripping and breaking circulation result in greater surge pressures, which all-too-often fracture the formation leading to whole mud losses. While both performance and environmental characteristics make synthetic-base fluids ideal for the deepwater, whole losses of these premium fluids can be prohibitively expensive.

The newly engineered system appears to overcome this concern by maintaining a lower rheology at cold temperatures when compared to other synthetic-base drilling fluids. Therefore, it essentially eliminates the adverse effects of cold temperature on both viscosity and gel strengths. In addition, solids contamination seems to have little adverse impact on either rheology or gel strengths.

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Many conventional synthetic-base fluids address cold water issues simply by lowering the viscosity. Doing so means the overall rheological profile will decrease in proportion with lowering temperatures. Simply lowering the viscosity does not take into consideration other performance issues common to most drilling operations, such as hole cleaning, barite sag and cuttings suspension. The newly developed synthetic-base system maintains consistent 150ºF mud properties even when confronting lower temperatures.

WHY FLAT RHEOLOGY?

With a flat rheology drilling fluid the mud properties maintain constant values at mud-line temperatures of 40º F; flow-line temperatures that typically are between 55-70º F in deepwater; bottom-hole circulating temperatures, and the standard API 150º F mud check temperature. Conceptually, a system behaving in this fashion can be expected to drill a well at lower equivalent circulating densities (ECD), encounter fewer problems drilling, and successfully avoid lost circulation problems. With a flat rheology system, the onsite drilling fluid engineer is able to design a fluid that can be effective under all downhole temperatures and pressures conditions. The cold temperature rheology does not become excessive and the high-temperature bottom-hole rheology parameters do not decrease to dangerous levels.

Since the properties do not have to be compromised at one temperature to satisfy requirements of a different temperature elsewhere in the well, the flat rheology profile greatly simplifies the design of the drilling fluid,. Often in deepwater drilling operations, the surface rheology must be reduced in order to decrease the rheology and ECD when encountering cold temperatures. Consequently, what often results is poor hole cleaning, barite sag or other downhole drilling problems related to low rheology at bottom-hole static and circulating temperatures. Conversely, adjusting the rheology upwards to compensate for higher bottom hole temperatures can lead to excessive ECD values, excessive gel strengths and pressure spikes that can break down the formation and lead to lost circulation.

Managing the rheology of conventional synthetic-base systems poses a very difficult challenge. With this new generation system, the unique flat rheology profile eliminates those difficulties and opens the door for more efficient drilling. From a hydraulics modeling standpoint, the new system allows the user to identify the optimal properties and design a mud system incorporating those properties over a broad range of temperatures.

ECD MANAGEMENT

Often in deepwater, aggressive rates of penetration can lead to accumulation of cuttings in certain parts of the well. Thus, during connections the cuttings will settle around the bottom hole assembly or drill string tool joints, causing pressure spikes once the mud pumps are returned to operation. Consistent fluid properties help to avoid this problem.

In the field trials, the superior cuttings transportation properties of the new system translated into smoother ECD profiles. Since the rate of cuttings removal managed to keep pace with the rate of cuttings generated, there was no accumulation of heavy cuttings in the annulus to gradually increase the ECD. In addition, since the constant yield point ensured efficient hole cleaning throughout the wellbore, pack-offs were avoided.

The new system also was successful in eliminating pressure spikes on connections. During the static period, the gel strengths that develop can result in pressure build-up that can break down the formation when the pumps are restarted. Since the flat rheology profile fluid has low clay content, the gels are not excessive. Combining this property with efficient drilling practices, such as rotating the pumps prior to starting the pumps, effectively eliminated the pressure spikes seen previously with conventional synthetic-base fluids.

Most noteworthy is the higher yield points, measured at 150º F, than those observed with conventional synthetic-base drilling fluids. Thus, the high yield points at 150º F did not translate into extremely high yield points at mud-line conditions. Accordingly, the high apparent yield point actually improved the ECD by providing superior hole cleaning performance.

PERFORMANCE SUMMARY

In order to analyze drilling performance, the 24 hour average drilling rate of the new system was compared to existing data from wells using conventional synthetic-base fluids. The newly engineered system was introduced to the 13 5/8-in. casing interval, where offset wells recorded 24 hour average rates of penetration of 53 ft/hr. With the flat rheology fluid the average increased to 83 ft/hr. The average measured depth for each of these intervals is around 3,600 ft, translating to a time saving in excess of 24 hours of on-bottom drilling time. In the deepwater environment, a time saving of this magnitude for one interval, readily translates into large savings for the operator over an entire well.

The key factor in achieving a higher average rate of penetration with the new fluid system is the balanced yield point. Therefore, hole conditioning time can be reduced dramatically due to the better cuttings transport ability of the fluid, with no need to halt drilling to circulate the hole clean and lower the ECD. Previously, to obtain optimal hole cleaning properties in the open-hole section, the properties in the riser or cased section of the hole were not necessarily ideal. In addition, the new system exhibited improved displacement characteristics when compared to conventional synthetic systems and delivered ECDs at least 0.1 lb/gal lower.

Although these initial observations were very encouraging, more field trials will be required to validate these results. ■