An increase in drilling activity in deep oil and gas reservoirs has created industry demand for stable water-based drilling fluids capable of withstanding high-temperature environments in cases where invert emulsion fluids were preferred. Conventional biopolymers fail near 300°F over short periods, and standard synthetic polymers could be stable at high temperatures but do not provide the low-end rheology to suspend solids. Drilling fluids that do not maintain stability in high temperatures require extensive fluid conditioning.

VeraTherm high-temperature, water-based drilling fluid from M-I SWACO, a Schlumberger company, delivers stability above 400°F, exhibiting excellent low-end rheology for hole cleaning and suspension while providing minimal fluid loss at high temperatures. The fluid is compatible with most oilfield completion fluids, from freshwater to near salt-saturated brines. The ability to prepare the fluid at the rig site adds flexibility to operations.

The fluid is applicable in high-temperature, water-based scenarios including drilling, logging, screen running, deep water, coiled tubing (CT) drilling, and fluid loss control pill or suspension pill. The water-based drilling fluid withstands up to 400°F without any treatment or property reduction over time and enables multiple logging runs without circulation, eliminating conditioning trips and a day of rig time with each avoided trip in high-temperature applications. It is compatible with common drilling fluid additives such as shale inhibitors, corrosion inhibitors and H₂S scavengers.

The VeraVis branched synthetic polymer viscosifier and fluid loss additive, the main component of VeraTherm fluid, provides dual function, delivering rheological properties and fluid loss control. By offering excellent solid suspension properties even at higher temperatures, it eliminates sag issues. Unlike synthetic polymers that have been used in different applications within the oil and gas industry for more than 50 years, the VeraVis additive contains unique chemical modifications. The branched nature of the synthetic polymer provides drilling fluid properties similar to conventional biopolymers such as xanthan, diutan and starch. This feature enables a significant reduction in formation damage compared to the linear synthetic polymers available in the market.

Many conventional water-based drilling fluids contain clay, which causes gelation issues at higher temperatures. Because the high-temperature, water-based drilling fluid is a clay-free system, no gelation issues occur across the full temperature and density range. The addition of proper lubricants produces drilling performance comparable to oil-based mud (OBM) and synthetic-based mud (SBM) systems.

The high-temperature, water-based drilling fluid provides excellent drilling fluid parameters performance, which includes high low-end rheology, low pump pressure, excellent fluid loss control, inherently low coefficient of friction and superior shale inhibition properties. It remains stable for longer durations at high temperatures (Figure 1).

Using the fluid in place of SBM reduced the operator’s overall drilling fluids cost. The use of one system through intermediate and reservoir sections reduces the environmental footprint.

Case studies
M-I SWACO has completed several successful field trials for the high-temperature, water-based drilling fluid in different global regions and various applications including CT drill-in fluid, logging pill, high-temperature...
drilling fluid and HP/HT drilling fluid. The case studies also cover a wide range of temperatures from 290 F to 380 F and densities from 8.8 lbm/gal U.S. (1.05 SG) to 16.5 lbm/gal U.S (1.98 SG).

In Southeast Asia, high-temperature zones, faults and fractures caused an operator to experience average losses of 5,000 bbl to 10,000 bbl per well while drilling an 8½-in. section. The operator sought a cost-effective, high-temperature, water-based fluid system offering drilling fluid performance similar to synthetic-based systems. The challenge required stability up to 365 F for five days while drilling the high-temperature well reservoir sections and facing heavy losses. Ideal rheological properties would enable excellent hole cleaning and minimize equivalent circulating density and losses while drilling.

The high-temperature, water-based drilling fluid maintained stable rheological properties for five days at 365 F. A 1% lubricant addition reduced the coefficient of friction of the fluid from 0.21 to 0.143 before aging and to 0.128 after five days rolling at 365 F. The fluid had a coefficient of friction that was similar to SBM, which is 0.125. Compared to immersion field tests of synthetic-based systems, VeraTherm fluid exhibited better shale inhibition. Rheological properties of the system remained constant and maintained fluid stability throughout drilling operations.

In another case study, an operator in the Middle East sought a high-temperature, water-based drilling fluid with high stability to drill high-temperature exploration wells. Offset data showed a prevalence of barite sag, unsuccessful logs and severe lost circulation. High-temperature OBM systems were not considered cost-efficient for this project because of the expected lost circulation in limestone formations.

The well contained 8½-in. and 6¼-in. potential reservoirs. Challenges included drilling highly reactive shale in formations with a bottomhole static temperature (BHST) for extended wireline operations lasting seven days at 330 F BHST and 375 F BHST while maintaining a minimal sag index. Customized and tested for stability at 330 F and 375 F, the high-temperature, water-based drilling fluid maintained stable rheological properties for more than seven days and obtained an excellent sag index of <0.52 for both interval formulations. The system caused no incidents of stuck pipe, wellbore instability or poor hole cleaning while drilling. The extensive wireline logging operation at 375 F was successfully completed. The fluid maintained rheological and fluid loss properties throughout the seven-day logging operation (Figure 2).

The high-temperature, water-based drilling fluid has broad environmental acceptance. In addition to the Southeast Asia and Middle East regions, it can benefit areas that contain excessive produced water with elevated divalent salts. Most water-based drilling fluids are not compatible with this type of produced water. Because the fluid is compatible with produced water containing divalent salts, it enables operators to use produced water from the field instead of freshwater, reducing the demand for additional resources. The fluid also presents opportunities for applications such as CT drilling, which requires a polymer that does not create high frictional pressure. The branched synthetic polymer has satisfied the requirements for CT drilling fluid and has successfully drilled two high-temperature wells.

**Conclusion**

Extended wireline operations and high-temperature wells require fluids capable of providing excellent thermal stability to maintain sufficient rheology and fluid loss control. Operations using conventional biopolymers could require numerous products to generate those properties, but the VeraTherm fluid contains the only primary VeraVis additive and a few additives requiring minimal treatment to maintain properties. With a long shelf life and the ability to succeed in a broad range of applications and temperatures, the fluid provides an efficient, economical alternative to other high-temperature, water-based fluids or synthetic-based fluids.