

# Drilling fluid work aimed at tough reservoirs, wells

**DEMANDS ON TODAY'S** drilling fluids are as severe as on any element of the drilling process. Presentations prepared for the 2002 IADC/SPE Drilling Conference, 26-28 Feb in Dallas, highlight new fluids now available and ways to get more performance out of traditional drilling muds. Two sessions, "High Performance Drilling Fluids," and "Improving Fluid Performance," at the Conference are chaired by **E Malachosky, Baker Hughes Inteq** and **P D Scott, Marathon Oil Co.**

## HTHP WELLS

How formate brine was used as drilling and completion fluid in the North Sea is the focus of IADC/SPE paper 74541, "Drilling HTHP Wells Using a Cesium Formate Based Drilling Fluid." The paper is authored by **A Saasen and O H Jordal, Statoil ASA; D W Burkhead, Conoco Inc; P C Berg, G Loklingholm and E S Pedersen, Statoil; and J B Turner and M J Harris, Cabot Specialty Fluids.**

For the first time anywhere in the world, the cesium formate brine was chosen as a drilling fluid. This fluid could be delivered solids free with densities up to 2.2 sg. The required down hole density in the well was 1.91 sg. At the same time it was necessary to have as little contribution to the ECD from the flow as possible. The cesium formate has been used successfully in drilling and completing a series of wells in this particular field, the authors report.

Difficulties in logging while drilling arise from both the nuclear properties of the formates used and having a drilling fluid filtrate density comparable with the formation densities.

During drilling in the North Sea field, high pressure and high temperatures were expected and encountered. The difference between the pore pressure and the fracturing pressure is relatively small. Cesium formate had been evaluated as a potential drilling and completion fluid, but technical hurdles could not be completely addressed in time for the first well.

## INHIBITION EFFECT

Shale inhibition is the most important factor in preventing hole problems when drilling with water based drilling fluid (WBM). Some products are believed to be vital for well bore inhibition, like a high concentration of KCl and glycols.

The effect of the products is largely based on the cuttings quality seen in the return flow at the rig. When new systems are introduced they are often tested in relatively simple wells and performance is evaluated based on results from that well.

IADC/SPE paper 74544 reports results from a survey of hole quality in North Sea wells and explains the use of indicators to measure hole quality. "The Drilling Fluid Inhibition Properties Effect on Hole Quality—A Well Survey," was prepared by **G Loklingholm, Statoil.**

The fact that some systems not regarded as inhibitive outperformed the state-of-the-art water based drilling fluid systems triggered a larger survey on drilling efficiency with respect to drilling fluid system. All water based drilling fluid systems used in Statoil's operations over the last 15 years in the North

Sea were compared based on hole quality. Survey data show that today's highly inhibitive systems are not performing any better than systems used 15 years ago, raising questions about how drilling fluid systems are designed today.

A method using "indicators" as a measure of the hole quality considers stuck pipe frequency, tripping time, drilling progress, caliper data and cuttings quality. As a result of the first part of the survey, the drilling fluid chemical composition was altered when drilling both non-reactive and reactive formations, increasing drilling efficiency.

## INVERT EMULSIONS

It has long been recognized that there exists a significant technology gap between the performance of the best water-based drilling fluids (WBF) and invert emulsion fluids. WBF fall behind with respect to shale inhibition, wellbore stability, rate of penetration and fluid stability; thus oil-based and synthetic-based drilling fluids remain the technical choice for drilling demanding wells.

The results of a number of extensive research and development projects into shale inhibition, cuttings accretion, lubricity, cuttings encapsulation and rate of penetration with water-based drilling fluids allowed the generation of a novel water-



**Restrictions on the use of invert emulsion fluids and the challenges of deepwater drilling have driven the development of water-based fluids.**

based drilling fluid designed to approach invert emulsion fluid flexibility and performance.

IADC/SPE paper 74543, "Novel, Inhibitive Water-Based Drilling Fluid: Have We Reached the Goal of an Effective Invert Emulsion Fluid Alternative?" describes the development of a water-based drilling fluid designed for global application and the initial field testing of this fluid. The paper was prepared for the Conference by **C Aldea, J E Friedheim, B J Toups, and S Young, M-I LLC; and E van Oort, Shell E&P Co.**

## ALTERNATIVES TO OIL

The ultimate objective of most water-based mud development programs has historically been a water-based mud with oil-based or synthetic-based mud performance. The perceived weaknesses of water-based muds in shale, relative to oil-based

or synthetic-based muds, typically are slow penetration rates (especially with PDC bits) due to balling and poor borehole stability.

Much time, effort and money have been spent trying to overcome these weaknesses. The net result is that oil-based muds/synthetic-based muds are now more popular than ever, according to the authors of IADC/SPE paper 74542. They suggest that a more productive approach to matching oil-based mud performance today is one that simultaneously addresses both borehole stability and drilling efficiency and one that builds on the best proven technology in the industry.

The authors report on the experiences of the **Woodside Energy Ltd** MODU group drilling in the North West Shelf and Timor Sea of Australia with a specific water-based mud design/PDC bit combination.

“Water-Based Alternatives to Oil-Based Muds: Do They Actually Exist?” was prepared for the Conference by **R G Bland**, Baker Hughes Inteq; **R J Waughman**, Woodside Energy Ltd; **R C Pessier** and **M R Isbell**, **Hughes Christensen Co**; and **W S Halliday**, Baker Hughes Inteq.

## GEOTHERMAL GROUTING

---

Polyurethane grouting has been successfully applied to a lost circulation zone in a geothermal well at Rye Patch, Nev. IADC/SPE paper 74556, “Polyurethane Grouting Geothermal Lost Circulation Zones,” by **A J Mansure**, **Sandia National Laboratory**, describes the project.

Previously, the zone had resulted in the temporary abandonment of the well after 20 cement plugs, including 15 conventional, 2 thixotropic and 3 with foam cement were unsuccessfully tried in attempts to plug the zone. Advantages of polyurethane grout include the fact that its viscosity and setting time can be controlled to fit the job. The material can be engineered to have a low viscosity while being pumped and then gain strength in a short period, minimizing waiting-on-cement and the potential for the plug to be washed out.

Polyurethane has been successfully used in core drilling operations (slim holes) to stop lost circulation and stabilize boreholes; however, previous attempts to apply polyurethane grouting to large diameter geothermal boreholes have not been successful.

The success of the grouting of the loss zone at Rye Patch was a result of packing off the hole and squeezing the grout, using sufficient polyurethane to sweep away the drilling mud, and controlling the gel time to be shorter than the injection time, according to the authors.

## MEMBRANE EFFICIENCY

---

IADC/SPE paper 74557 covers efforts to develop a water-based drilling fluid that will provide the osmotic membrane behavior and wellbore stability of an oil-based drilling fluid. “Membrane Efficiency in Shale—An Empirical Evaluation of Drilling Fluid Chemistries and Implications for Fluid Design,” was prepared by **R P Schlemmer** and **J E Friedheim**, M-I LLC; and **J B Bloys**, **J A Headley** and **S C Polnaszek**, **Texaco Inc**.

A pore pressure transmission technique in use for several years as a tool to measure osmotic behavior has been refined

for improved measurement of changes in shale permeability and pore pressure in response to fluids interactions with outcrop and preserved shale specimens. Conventional invert emulsion and water-based drilling fluids containing selected additives have been tested in this ongoing study.

Data support the notion that oil-based drilling fluids do not necessarily yield a perfect osmotic membrane.

Membrane efficiencies of far less than 100% have been measured with invert emulsion fluids. Also, the nature of the salt in the brine phase, not just its concentration and resultant water activity, may affect the performance of an invert emulsion fluid. Physical and chemical properties of the invert emulsion fluid affect the membrane efficiency and the osmotic process.

The assumption that the specification of a salt and a concentration for the brine phase of an invert emulsion fluid is sufficient for assuring generation of an effective drilling fluid may be incorrect.

## HOLE CLEANING

---

Hole cleaning is still among the most important problems in drilling. The difficulty in removing the cuttings bed during drilling arises because the drilling fluid interacts with the cuttings in the cuttings bed to form a cuttings bed gel.

In IADC/SPE paper 74558, the authors explain the effect of the cuttings bed properties on hole cleaning and demonstrate how

drilling was improved compared to earlier operations using conventional drilling fluids. "The Effect of Drilling Fluid Rheological Properties on Hole Cleaning," was prepared for the Conference by A Saasen and G Loklingholm, Statoil.

The drilling fluid composition can be designed to minimize the gel formation in the cuttings bed. At the same time, the drilling fluid properties are optimized to ensure a sufficient shear stress on the cuttings particles to be able to remove the cuttings, according to the authors.

This technique has been used in several of Statoil's drilling operations.

Drilling operations in 2 North Sea fields show how the total drilling progress, including tripping in and out times, is increased. Torque curves of comparable wells demonstrate that hole cleaning has been significantly improved.

## EXTENDED REACH

A North Sea operator intended to drill a 16-in. wellbore with a long highly-deviated trajectory (5,400 ft MD, 20-63° deviation) in the Central Graben of the North Sea. As a result of changing UK environmental legislation, the utilization of mineral-oil-based muds requires all cuttings be shipped back to shore for processing and disposal.

Due to the expected large volume of drilled cuttings in this interval, water-based mud (WBM) alternatives without disposal problems were investigated.

In IADC/SPE alternate paper 74545, the authors report on the use of a water based drilling fluid in an extended reach well. "Successfully Replacing Oil-Based Drilling Fluids with Water-Based Drilling Fluids: Case Study Demonstrates Value of Extensive Planning and Execution in Extended-Reach Well," was prepared for the Conference by **T Hemphill and U A Tare, Baroid/Halliburton**; and **K Morton, Chevron Drilling**.

Wellbore instability is a major issue in the Central Graben. As water-based muds have had little success in achieving good hole stability in the area, the use of invert emulsion drilling fluids has prevailed.

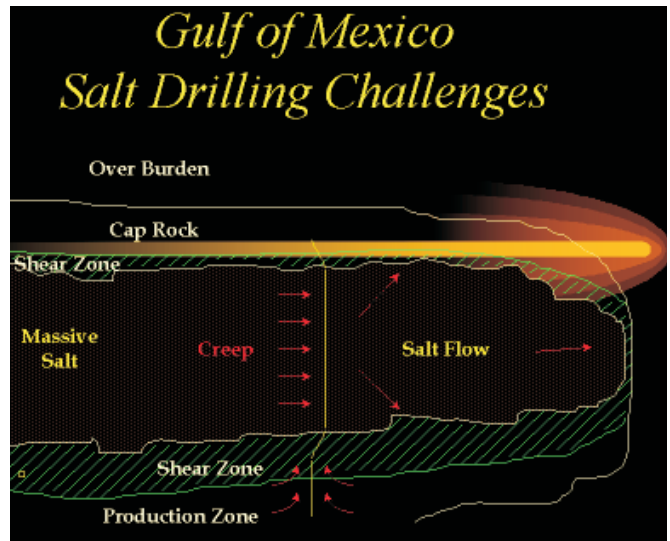
For this project, samples of highly reactive shales were analyzed and an in-depth wellbore stability study helped optimize mud weight requirements. An inhibitive WBM that contained KCl/glycol/shale-stabilizing surfactant was then formulated to meet the drilling challenges.

The limited mud pump capacity coupled with the planned large diameter wellbore served to compromise hole cleaning efficiency, the authors report.

To avoid pack-off incidents, tight hole, etc, hole cleaning modeling was performed during planning to maximize drilling efficiency. Hydraulic simulations were also run to obtain predictions of ECD as functions of several drilling parameters.

Drilling the challenging interval with water-based mud was characterized by excellent wellbore stability, good cuttings integrity and easily-controlled mud properties.

Adequate hole cleaning efficiency and ECD levels near those determined in pre-well simulations were successfully achieved with no drilling fluid-related downtime.



## DRILLING SALT

Drilling a deep, high-pressure subsalt well is expensive and a mechanical challenge. IADC/SPE alternate paper 74546 explores synthetic-based mud (SBM) versus water-based mud (WBM) and the efficacy of using a controlled washout approach with WBM. "Drilling Salt—Improved Penetration Rates," was prepared for the Conference by **D L Whitfill, Halliburton Energy Services**; **W K Armagost, BP plc**; and **J R Lawson and G Rachal, Halliburton Energy Services**.

Drilling fluid selection in the past has focused on drilling a gauge hole, with little concern about penetration rates.

Should a water-base mud or a synthetic oil-base mud be used? Should you drill a pilot hole and then under-ream, under-ream while drilling or drill without under-reaming by using a bi-center bit? If water-base muds are selected, can you use a controlled washout approach to either replace under-reaming, or make it faster?

## ELASTOMER ADDITIVE

Loss circulation continues to be the primary trouble cost for synthetic drilling fluids used in the Gulf of Mexico. IADC/SPE alternate paper 74559 introduces a recycled elastomer that has exhibited unique characteristics, resulting in a better method for managing severe losses as well as seepage losses.

"Elastomer Additive for Inverts Provides a Deformable LCM That Expands Within Fractures," was prepared for the Conference by **R R Wood, NER International**.

The rubber used for the product has been ground to maximize fracture plugging as currently practiced. Along with proper particle sizing, the rubber expands up to 120% of its original size when exposed to temperature yet remains insoluble in oil. This allows the particles to penetrate fractures and swell to a point of confinement.

Test data and experience demonstrate the improved performance of the elastomer LCM over currently used fiber, calcium carbonate and graphitic products, the authors report.

The recycled elastomer is temperature stable to 500 degrees F, non-soluble in oil and environmentally safe. ■