# Advanced BHAs extend capability, boost efficiency

**THE GROWING COMPLEXITY** of well trajectories and the increased length of horizontal hole sections have driven innovation in bottomhole assemblies. Those advances have also made the collection of downhole date more critical to success.

From complete new well construction systems to improvements in more traditional technology, the bottomhole assembly is steadily becoming more sophisticated.

**Toni Marszalek**, **Schlumberger Oilfield Services** and **Dan Scott**, **Hughes Christensen** are to chair a session at the 2001 SPE/IADC Drilling Technology Conference, "The Instrumented BHA," that will detail today's BHA technology. Papers prepared for the session focus on advances in steerable systems and field experience with new tools and methods.

## REDUCING TORTUOSITY

Wellbore tortuosity can be defined as any unwanted deviation from the planned well trajectory.

As wells become more complex, oil companies increasingly perceive wellbore tortuosity as a concern in drilling, completing and producing wells. In specific applications, excessive tortuosity in horizontal wells can even impair productivity.

A Drilling Conference paper describes the results of a tortuosity analysis of a number of North Sea wells drilled with rotary steerable systems and offset wells drilled with steerable motor systems.

Paper 67715, "Drilling with Rotary Steerable System Reduces Wellbore Tortuosity," was prepared by **P-J Weijermans**, **H Jamshidian** and **M Matheson**, **Shell UK Exploration and Production**, and **J P Ruszka**, **Baker Hughes INTEQ**.

The authors note that due to the conceptual difference in steering principle between conventional directional drilling systems utilizing steerable bent housing motor technology, and rotary steerable systems, it has been claimed that rotary steerable systems produce a less tortuous wellbore.

This effect has so far not been quantified, mainly due to the absence of sufficient data.

The authors' analysis shows that drilling with rotary steerable systems significantly reduces tortuosity.

In tangent sections drilled with the rotary steerable system, superior inclination hold performance was observed

Study of North Sea wells shows drilling with rotary steerable systems reduces tortuosity.

and in areas of the wellbore where deviation changes were planned, more continuous curve sections were drilled.

To illustrate potential benefits this may have with respect to drilling conditions, results from the evaluation were used to carry out torque/drag simulations. Levels of tortuosity produced by steerable motor systems and rotary steerable systems were calculated. These values were superimposed on a generic well profile.

It was found that the torque reducing effect of the lower tortuosity delivered by the rotary steerable system is quantifiable and in some cases significant.

## POINT THE BIT

**S Schaaf** and **D G Pafitis**, **Schlumberger Oilfield Services**, in a paper prepared for the Drilling Conference, describe a point-the-bit type rotary steerable system in which all elements that contact the wellbore rotate at the bit speed.

In paper 67716, "Field Application of a Fully Rotating Point-the-Bit Rotary Steerable System," the authors say this approach provides numerous advantages including improved hole cleaning and reduced risk of stuck pipe.

Examples presented in the paper where the system has been used to drill commercial wells identify the improvements in overall drilling performance that can be achieved through the use of the point-the-bit rotary steerable system.

## USING PWD TOOLS

In their paper prepared for the conference, **G R Samuel**, **Landmark Graphics Drilling & Well Services** and **C Ward**, **Sperry-Sun** present surge and swab field data during tripping and circulating operations collected using Pressure While Drilling (PWD) tools.

Paper 67717 is titled, "Field Validation of Transient Swab/Surge Response with PWD Data."

Data presented were obtained from Alaska and North Sea wells ranging from super slim holes to larger diameter holes with different base fluid muds.

The data were compared with a dynamic surge model, which includes the effects of fluid inertia and compressibility, wellbore elasticity, axial elasticity of the pipe, and temperature dependent fluid properties. The transient response of measured downhole pressure, surface pump pressure, return fluid flow, and hook load are compared with the model and interpreted.

The authors report that seven tests were performed in Alaska and three in North Sea.

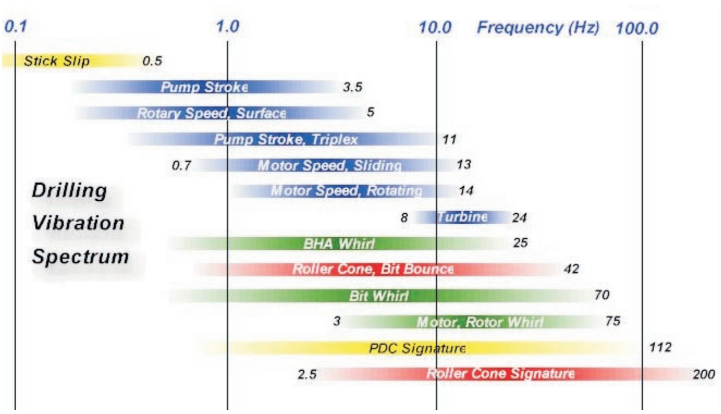
Sensitivity tests were run to observe the effects of plastic viscosity and yield point in some wells. Different operations were included in the PWD runs to cover swabbing, surging, reciprocation and simultaneous pumping operations during tripping.

The actual PWD data showed excellent agreement with the model predictions of downhole pressure, surface pump pressure, return fluid flow and hook load, according to the authors.

The practical usefulness of the theory, backed by the fundamental analysis, is demonstrated with five field cases.

These cases also highlight several non-intuitive transient effects such as observation of surge effects while swabbing and vice versa and the effects fluid properties on high pressure/high temperature wells.

The data clearly show dynamic and inertial effects not anticipated by conventional practices but predicted by the model.




In the drilling vibration spectrum from 0.1 to 100 Hz, torsional vibrations are yellow, axial vibrations red and lateral vibrations green. Blue bars are sources that may excite resonances (and cause detrimental vibrations).

## RETRIEVABLE MWD TOOL

As the search for recoverable oil reserves moves to smaller, deeper, and hotter wells, MWD operating conditions have grown increasingly difficult.

MWD tools must survive temperatures to 350 ºF, pressures to 20,000 psi, and a wide variety of mud conditions.

Moreover, deep wells stress an MWD telemetry system's ability to deliver reliable measurements in real time.

In their Conference Paper, "New Generation Retrievable MWD Tool Delivers Superior Performance in Harsh Drilling Environments," the authors describe the development of a new generation retrievable MWD tool that can deliver the reliability required even in deep, hot wells. Paper 67718 is authored by **P K Till**, **J-M Hache** and **T Skillingstad**, **Schlumberger Oilfield Services**.

The first-generation retrievable MWD tool operated in temperatures to 350 ºF. Experience gained from over 20,000 operating hours tool above 300 ºF was used in the design of the new tool.

Three case studies demonstrate the tool's performance:

• In Jasper County, Tex, this new MWD tool was five times more reliable than the previous generation tool. The final run lasted 193 hours without a failure at a maximum temperature of 330 ºF;

• In the Villafortuna field in Italy, over 300 hours of reliable MWD service were delivered at depths greater than 20,000 ft with downhole pressures exceeding 20,000 psi and a maximum circulation temperature reaching 356 ºF;

• In Navasota, Tex, the tool operated for more than 400 hours with temperatures from 300 ºF to 338 ºF. One run lasted 111 hours at 316 ºF. There were no telemetry problems despite the difficult mud conditions of 17.7-ppg mud weight, 28-lbm/bbl LCM, and 27% hematite.

## BETTER MEASUREMENT

The measurement of mud motor rotation rates and the transmission of these measurements to surface while drilling is important for drilling optimization.

In Drilling Conference paper 67719, "Measurement of Mud Motor Rotation Rates Using Drilling Dynamics," the authors describe a means of measuring the rotation rate of a mud motor using a device that is independent of the mud motor. The presentation was prepared by **J D Macpherson**, **P N Jogi** and **B E Vos**, **Baker Hughes INTEQ**.

In general, mud motor rotation rates are estimated from the manufacturer's performance data. However, the authors say flow rates, torque, weight on bit and differential pressure will all vary while drilling as will the efficiency of the motor.

While torque, weight and pressure can all be measured by MWD tools, the direct measurement of motor speed has proven difficult. In general it has been necessary to instrument and hardwire a motor to the MWD sub in order to measure motor speed.

In essence, the dynamic signal created by the rotor is detected by vibration sensors in an MWD measurement sub in the BHA, and converted directly to motor speed.

## ERD WELLS

In an alternate paper prepared for the Conference, **J Cushnie** and **B Montaron**, **Schlumberger Oilfield Services-Drilling & Measurement**, describe the first application of extended reach drilling in the Middle East.

In paper 67720, "Extended Reach Drilling, First Application in the Middle East," the authors present an overview of the drilling philosophy for the field and describe how an extended reach well helped achieve the objectives.

In one example, data indicated that conventional drilling would take 16 days to complete the section, while rotary steerable drilling would achieve the same footage in 11 days.

## ROTARY CLOSED LOOP

New rotary steerable drilling technology was introduced to the **Chevron** Alba field in an effort to optimize horizontal well placement in the reservoir and extend the production life of the field. In alternate paper 67721, "The Value of Rotary Closed-Loop Drilling Technology on Chevron Alba's Horizontal Field Development," **G R Holmes**, **Chevron UK** and **J A Johnstone**, Baker Hughes INTEQ, described this application.

Initial development of the field utilized conventional drilling technology—steerable motor assemblies and rotary drilling assemblies with adjustable stabilizers.

Due to geological uncertainties, directional plans routinely featured pilot holes with one or more geological sidetrack options. Well designs were constrained by the limitations of conventional technology. Specifically, the limited ability to steer in the unconsolidated reservoir sands meant utilizing three-cone bits in preference to PDC bits.

The authors report that this application of the rotary closed-loop system (RCLS) demonstrated that it was possible to steer within the Alba reservoir and thus allow the horizontal wellbore to be placed optimally in the reservoir.

RCLS also minimized exposure to intra-reservoir shales along the production wellbore and thereby significantly increased the probability of successful gravel packing operations. The RCLS enabled reduction in operational costs by:

• Drilling 12¼-in. and 8½-in. hole sections faster;

• Obtaining efficient hole cleaning throughout the well, thus reducing the incidence of hole packoffs and stuck pipe;

• Being able to perform open hole sidetracks without tripping for a BHA change. ■