Technologies address unique deepwater problems

DEEPWATER DRILLING presents special technical challenges.

The ocean environment makes special demands. The high cost of deepwater operations increases the pressure to constantly improve efficiency. And unique pressure and temperature gradients that characterize drilling in water depths as great as 2,000 m of water must be well understood in order to ensure borehole stability and well control.

New deep drilling technologies are battling these challenges on a variety of fronts. At the 2001 SPE/IADC Drilling Conference, the session "Deep Water Drilling Technologies" highlighted the range of these efforts.

The session is to be chaired by **R Cesaroni**, **Saipem** and **T Duhen**, **Pride International**.

DUAL GRADIENT

The advantages of a dual gradient mud column have been well documented. Significant work has been done on the riserless drilling systems by several different companies.

In SPE/IADC paper 67745 prepared for this session, "Two Methods for Achieving a Dual Gradient in Deepwater," authors **R P Herrmann**, **Consultant**; and **J M Shaughnessy**, **BP**, propose two methods to achieve a dual gradient.

Figure 1: Concentric risers

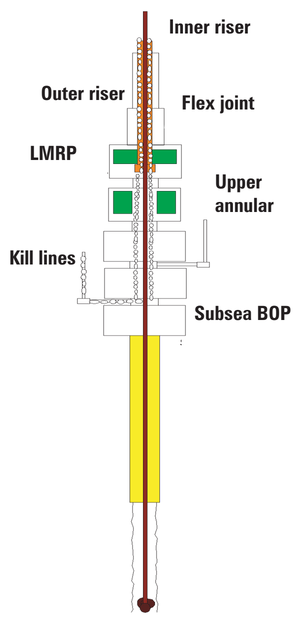
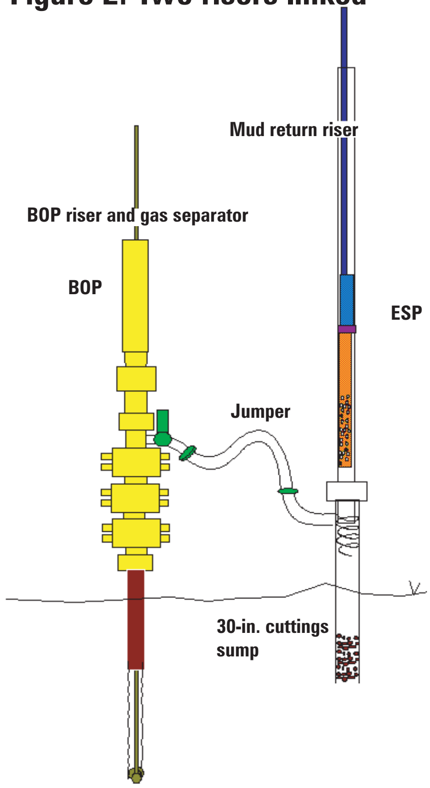


Figure 2: Two risers linked



The first method (Figure 1) is nitrogen injection.

Building from proven air drilling procedures and underbalanced techniques nitrogen can be used to cut the mud weight back in the riser above the seafloor or the cut can be made deeper by combination with a concentric riser.

The second approach (Figure 2) described by the authors is the floating mud cap. A dual activity rig can use a casing riser linked to the adjacent marine drilling riser. A submersible pump in the casing riser regulates returns that will set the mud cap level in the drilling riser.

A pressure sensor in the subsea BOP allows monitoring the effective hydrostatic pressure. This approach again combines field proven procedures and hardware in the deepwater environment.

In presenting both methods, the authors emphasize the hardware and operational procedures required to successfully implement them.

REMOVING HYDRATE PLUG

During deepwater well testing operations West of Shetlands, a hydrate plug formed in the test string inside the riser above the mudline. The water depth was 2,750 ft and the hydrate plug was a total of 1,350 ft long between the mudline and surface.

A coiled tubing operation was developed and implemented successfully to remove the hydrates safely and effectively.

In SPE/IADC paper 67746, "Case History of the Removal of a Hydrate Plug Formed During Deep Water Well Testing," **E Reyna**, **Conoco** and **R Stewart**, **Halliburton**, describe the operation to remove the plug.

During the coiled tubing operation, several potentially dangerous events occurred. But because they were identified in the planning stages and the rig was prepared for them, they were non-events.

The hydrate plug was successfully removed, and the well test resumed to a successful conclusion, according to the authors. In the paper, they focus on the operational practices used to remove the plug, including:

- How hydrate formation was masked by other aspects of the well test;
- The technical and operational issues considered while developing the procedure;
- The outline of the final procedure;
- Results of the execution.

OPTIMIZING P&A

Traditional methods for recovering a subsea wellhead required several trips to remove casing. The cost of deepwater operations now calls for a more cost effective approach.

In SPE/IADC paper 67747, "Using Multifunction Fishing tool Strings to Improve Efficiency and Economics of Deep Water Plug and Abandonment Operations," the authors discuss new procedures and equipment that can improve efficiency.

The paper was prepared for the Conference by **W Going**, **K Brumley** and **D Haughton**, **Baker Oil Tools**.

In the paper, they discuss procedures and tool systems developed to optimize the efficiencies and economies of subsea plug and abandonment (P&A) operations.

The tools and techniques described address removal of intermediate casing strings and final removal of the subsea wellhead. Included in the discussion is a new deepwater plug and abandonment system that employs a string of multi-function fishing tools designed to work cooperatively to minimize the number of trips required for casing and wellhead recovery.

This significantly reduces pipe-cutting time and prevents wellhead damage without the use of motors.

Before the development of multifunction fishing tools, recovering a subsea wellhead required three or more drill string trips to remove each string of intermediate casing, followed by another trip to cut and recover the wellhead.

During the 1990s, cut-and-pull technology consolidated cutting and recovery of the wellhead into a one-trip procedure. However, multiple trips were still required for each intermediate casing string.

Given today's rig rates for deepwater work and the amount of time required to cut the large-diameter, thick-walled casing that ties into subsea wellheads, it is easy to see why any opportunity to improve the efficiencies of subsea P&A operations is welcome.

The new systems and procedures addressed in this paper rely on proven technology to reduce risk and minimize field training required for successful deployment.

In the paper, the authors compare time and costs for old and new methods. And they describe a universal wellhead retrieval system and a unique procedural sequence in which casing is cut before seals are extracted, resulting in the ability to cut and recover the wellhead in a single trip without damaging the wellhead.

Also, the safety, environmental, and economical advantages of eliminating motors and explosives and cutting the wellhead in tension are explained.

Case histories quantify results in the Gulf of Mexico and West Africa.

Onshore test in a 1,300-m well was done before taking aerated fluid system offshore

USING AERATED FLUID

Drilling with a two-phase drilling fluid has increased recently due to the potential of minimizing or solving several problems, including formation damage, stuck pipe, mud losses, and low rate of penetration.

In SPE/IADC paper 67748, "Drilling with Aerated Fluid from a Floating Unit: Planning, Equipment, Tests, and Rig Modifications," the authors detail the steps taken in planning a project and describe the rig modifications that were necessary. The paper was prepared for the Conference by **H Santos** and **F Rosa**, **Petrobras**; and **C Leuchtenberg**, **Impact Engineering Solutions**.

Thousands of wells have been drilled onshore using this technique, including wells drilled underbalanced. Offshore application, however, has been limited to fixed platforms.

The challenge today is to drill wells from floating units.

A two-phase drilling fluid has been considered a good and viable alternative to minimize the risks of drilling wells in ultradeep water, where the fracture gradient is very low and mud losses have been observed in many situations.

According to the authors, this technique can be a good option to solve problems in deep water extended reach wells where long phases and narrow mud weight operational windows are common.

To overcome the difficulties of drilling with aerated fluid from a floater unit, Petrobras started a Joint Industry Project (JIP) "Offshore Drilling with Lightweight Fluids", with the main goal of studying the limitations and effectively implementing the technology.

In this paper, the authors present all the phases and steps taken by the project team in the pre-operation phase. The well to be drilled in the Albacora field has been planned in order to minimize the risks of this first operation.

Several new equipment items have been built especially to accommodate the restrictions of a floater unit, basically footprint restrictions. The separator, as well as the skids to control the well and the rotating control head, are all new developments.

Prior to taking the equipment offshore, a complete full-scale test was performed onshore on a 1,300 m test well. This step has been used to check and adjust all the settings, control and operational procedures.

Finally, the authors describe the rig modifications required to safely perform the operation. The platform is now adapted and ready to drill wells with this new option.

HYDRATE RISK

One of the many technical problems in deepwater drilling is the possible formation of hydrates in the BOP or choke and kill lines.

The problem is addressed in SPE/IADC paper 67749, prepared for the Conference by **J Petersen**, **K Bjørkevoll** and **K Lekvam**, **RF-Rogaland Research**.

"Computing the Danger of Hydrate Formation Using a Modified Dynamic Kick Simulator" offers an approach to minimizing the problem.

Planning offshore wells in deep water requires special tools to optimize operation and safety procedures.

Considering the risk of hydrate formation in the BOP or kill/choke line should be part of that planning.

Hydrates are ice-type substances consisting of frozen mixtures of water and hydrocarbons which may plug the BOP stack and well circulation path and will be very difficult and time consuming to remove.

An advanced dynamic kick simulator, developed at Rogaland Research, has recently been expanded to include the determination of the potential for hydrate formation.

Using dynamic temperature simulation, detailed PVT computations of the hydrocarbon influx on the component level, and an advanced hydrate formation program, it is possible to obtain the, "distance" in temperature from hydrate formation throughout the well at any time during a simulated operation.

The simulator includes code that takes into consideration the effect of hydrate inhibitor chemicals such as salts and alcohols.

Thus it is possible to make several trial runs with differently inhibited muds to compare the danger of running into hydrates, according to the authors.

The authors discuss the physical and chemical models used, and point out how to circulate in a way to minimize the chance of hydrate formation.

Simulating a kick with hydrate formation is a novel and significant contribution, according to the authors.

This will enable the industry to plan and engineer complicated well control situations. In particular it will allow the planning engineer to evaluate the risk of hydrate formation versus the cost of mud inhibition.

This will be very useful for low mud weight situations where providing hydrate inhibition is very expensive.

HORIZONTAL SUCCESS

Open hole horizontal wells are attractive in ultradeep water because the approach eliminates a liner and allows additional casing strings uphole.

This method also provides extensive reservoir exposure.

In SPE/IADC paper 67750, "Successful Horizontal Drilling and Gravel Packing in Deep and Ultra Deepwater," the authors discuss successful horizontal drilling and gravel packing experience. The paper was prepared for the Conference by **J Vozniak**, **S Mathis**, **G Ratterman**, and **K Smejkal**, **Baker Oil Tools**. It focuses on successful horizontal drilling and gravel packing from dynamically positioned drillships in water as deep as 3,330 ft in the Marlim field offshore Brazil.

Fifteen open hole completions have been successfully performed in the deepwater Marlim field, including both gravel- and non-gravel-packed completions in horizontal producers and injectors.

Also, three Level 5 multilateral wells with open hole completions have been successfully installed in the same field.

In the paper, the authors discuss experience gained and lessons learned while drilling and completing the open hole section of the reservoir. Pumping operations, use of extended-longevity well screens, and fluid systems to prevent formation damage are discussed.

Four of the 15 completions described above were drilled and completed from dynamically positioned drillships. One was successfully gravel packed in 3,330 ft of water, with the others ranging from 1,863 ft to 2,670 ft.

In this paper, the authors discuss how successful operations from dynamically positioned drillships pave the way for drilling and gravel packing in ultradeep water.

WATER BASED FLUIDS

Designing drilling fluids for deepwater offshore Norway provides significant challenges not encountered in other deepwater basins such as the Gulf of Mexico or offshore West Africa.

Although the deepwater basins to be explored off Norway are not in world record depths, the region does have very low temperatures at seafloor (-2 °C) as well as low ambient surface temperatures and constantly changing sea conditions.

When combined with strict environmental legislation, it makes engineering deepwater drilling fluids for offshore Norway a daunting challenge.

In SPE/IADC alternate paper 67834, "Design of Water Based Drilling Fluid Systems for Deep Water Norway," the authors describe the techniques used for qualifying the proper drilling fluid properties for an offshore well with multiple objectives.

The paper was prepared by **E Sorgard** and **E Alteras**, **Norsk Hydro**; and **A Dzialowski**, **G Fimreite** and **G Svanes**, **M-I Norge**.

The drilling fluid was to be hydrate inhibitive under normal drilling operations. Two different hydrate testers were qualified and used, both for initial design and QA of drilling fluids during the drilling of the well.

A novel hydrate prediction tool for drilling operations was also used.

Another objective was compatibility with formation water. The fluid had to be sulfate-free in order to be compatible with the formation water, so that a full DST could be avoided, saving the operator approximately $8 million.

The particle size distribution for the fluid was engineered in order to reduce the filtrate invasion.

Other objectives included:

- Environmentally acceptable for discharge of cuttings and excess fluids;
- Improved rheological parameters for cold temperature;
- Shale stability and shale drillability.

Multiple salts and glycols were used, and behavior of these was characterized prior to initiating drilling.

In the paper, the authors focus on the practical approach taken to qualify this novel deepwater drilling fluid, outlining steps for the non-fluid specialist to design deep water drilling fluids. ■