

Deep water adds demands on equipment, crews

AS DEEPWATER CAPABILITIES

grow, so do the challenges. But the potential reserves in water depths to 10,000 ft and beyond continue to drive technical and operational innovations.

The 2002 IADC/SPE Drilling Conference, 26-28 Feb in Dallas, features 3 deepwater sessions.

Deepwater Planning and Engineering is co-chaired by **F B Williford, Ensco International Inc**; Deepwater Operations I and Deepwater Operations II are co-chaired by **M E Rolleg, Santa Fe Snyder Corp** and **M R Plaisance, Diamond Offshore Drilling Inc**.

HANDLING GAS INFLUX

The authors of IADC/SPE paper 74517, "Gas-Influx Events in a Deep Water Exploratory Well: A Field Case History," discuss and evaluate control methods. The paper was prepared for the Conference by **A C Lage, P R da Silva, F A Borges, R B Mansano, R M Imanishi, and F S Martins, Petrobras**.

Several gas-influx events occurred during drilling ESS-107, an exploratory well in 1,286 m of water offshore the southeast coast of Brazil. The 9 5/8-in. casing was set at 3,804 m for drilling the final 8 1/2-in. phase of the program. Then, a sequence of gas-influx events significantly affected overall drilling performance.

The first influx while drilling at 4,719 m was initially diagnosed as over-pressured, the authors report. Consequently, after using the driller's method to remove the gas, the mud weight was increased from 11.3 to 12.5 lbm/gal.

After that, other well control incidents happened in sequence while drilling from 4,719 to 4,964 m. Despite the suspicion of a fracture breathing formation phenomenon, the mud weight was increased to 13.5 lbm/gal without halting flow of gas into the well. In addition, as water based mud was routinely flowing through the choke and kill lines mixed with gas, a pumping interruption caused the formation of hydrates. So both kill and choke lines were plugged.

The authors report this was the first occurrence of hydrate formation while drilling in deep water in Brazil.

RISERS IN CURRENT

In various parts of the world such as the Gulf of Mexico, Trinidad and Brazil, deepwater drilling operations can be interrupted by high currents, particularly while running riser. To counter this, a drifting procedure is used for running the drilling riser in high currents.

In this procedure, a dynamically-positioned vessel moves toward the well in the direction of the current as the riser is run. This process allows the riser to be run in higher currents than would otherwise be possible and avoids rig downtime while waiting for the current to subside. Running riser without drifting could lead to riser binding in the diverter housing, and could cause excessive stress in the riser pipe and damage to the foam buoyancy.

IADC/SPE paper 74486, "Simulation of the Drifting Process to Assist Riser Deployment in High Current," discusses a computational tool for estimating the vessel starting point in the drifting process toward the well. This estimate is made using an initial measurement of the current profile and minimizing the total drag force on the riser so that the riser stays in the center of the diverter housing.

In practice, the crew is able to monitor the riser's position within the diverter housing and propose vessel velocity adjustments to the captain. If the vessel goes beyond or falls short of the well-head, the causes could be numerous, including an increase or decrease in the current profile.

J N Brekke and M Wishahy, Global Marine Drilling Co, prepared the paper for the Conference.

NEW ANCHORING APPROACH

Exploration drilling in the ultra deep water Gulf of Mexico has been successful and operators are now making plans



Head sea model mooring test was part of the evaluation of new approach to anchoring semisubmersible in deep water in storms.

to develop those fields that have been proven commercial.

Drilling these fields will require special development drilling rigs to operate at single locations for extended periods.

Some operators have expressed a preference for semisubmersibles maintained on station with pre-set mooring lines attached to a rig-based conventional mooring system.

The challenge for the drilling contractor is to design and install the mooring system in a way that allows the rig to remain safely on station during a hurricane without compromising the efficiency of the arrangement in more benign environments not subject to tropical revolving storms.

IADC/SPE paper 74503, "A New Approach to Anchoring a Semi-Submersible in Deep Water Areas Subject to Tropical Revolving Storms," proposes one solution that makes unconventional use of the total capacity of a conventional combination chain/wire mooring system.

The paper was prepared for the Drilling Conference by **C N Springett, T Lay and J Soles, GlobalSantaFe**; **E Zimmerman, Delmar Systems Inc**; and **J Ottenhoff, Bowdewes Winches**.

"The challenge for the drilling contractor is to design and install the mooring system in a way that allows the rig to remain safely on station during a hurricane without compromising the efficiency of the arrangement in more benign environments...."

IADC/SPE paper 74503

The method allows the operator to increase the number of mooring lines in anticipation of hurricane season to substantially upgrade the capacity of the system at minimal additional cost. The arrangement also reduces the time it takes to attach the system to a pre-laid spread, reduces the exposure of personnel to injury while deploying the system and keeps the components to a manageable size for when the rig operates in areas not served by premium anchor handling boats.

The author cites GlobalSantaFe's new Development Driller as the example. The return period of the hurricane the rig can safely withstand is increased by running additional lines in both the conventionally moored situation in water depths less than 5,000 ft and in the pre-laid situation in water depths in excess of 5,000 ft.

Minor modification to the anchor winches allows them to support maximum load on traction winch and windlass simultaneously. Innovative positioning of the fairleaders increases the flexibility and utility of the system.

DP ANALYSIS

Conoco UK Ltd recently drilled an exploration well in 6,189 ft (1,886.4 m) of water in the northern Atlantic Margin, in a location 220-km off of the West Coast of the UK.

Potentially severe metocean conditions posed a significant challenge to the capability of the DP drillship selected to drill in this environment.

IADC/SPE paper 74485, "Methodology for Engineering Analysis for Deepwater Drilling in the Northern Atlantic with a Dynamically Positioned Drillship," shares the methodology used to ensure

that the rig equipment and vessel systems matched the needs of the harsh environment operation. The paper was prepared by K S Stewart, K M Kuchner and R A Mason, Conoco Inc; and E M Reyna, Conoco UK Ltd.

To better define and understand the overall vessel limitations for operating in the Northern Atlantic, CUKL performed an Operability Analysis which focused on vessel downtime, riser systems and station keeping capabilities.

These studies defined appropriate operational limits and confirmed that the selected shipshape vessel was indeed capable of operating in more severe metocean conditions than originally determined from the vessel's specifications, according to the authors.

The main systems examined during this study included the complete drilling riser, riser recoil system, emergency disconnect procedures, dynamic positioning and glycol injection.

PRE-DRILL INFORMATION

A recent western Gulf of Mexico well that was drilled in 4,900 ft water used a new pre-stack seismic velocity extraction and pore pressure estimation technique to provide the pre-drill information needed for an economical well design.

The well was ultimately drilled according to plan with no drilling surprises. The nearest offset well was 35 miles away.

IADC/SPE paper 74487, "Pre-drill Seismic Pore Pressure, Fracture Gradient, and Lithology/Pore Fluid Prediction Result in Deepwater Drilling Success," describes the project. J F Greve, eSeis Inc, prepared the paper.

The shallow nature of the geologic play necessitated an accurate pre-drill estimation of the pore pressures, fracture gradients, and lithologies. The well was permitted with the US Minerals Management Service (MMS) using only 2 strings of casing (36-in. structural and 13 3/4-in. surface casing). The setting point of the 13 3/4-in. shoe was vitally important in terms of getting as deep as possible to obtain the desired leak-off gradient without encountering any shallow water flows or hydrocarbon bearing intervals.

Both objectives were achieved using the

results from the new seismic processes, the author reports.

Logging-while-drilling and pressure-while-drilling downhole measurements were continuously monitored during the 9 7/8-in. pilot hole (opened to 16 in. for the 13 3/4-in. casing) and the final 12 1/4-in. x 13 1/2-in. hole to total depth.

During the 9 7/8-in. pilot hole, the gamma ray log was continuously correlated to the pre-drill seismic lithology (depth based prediction) and the resistivity used for pore pressure determination.

Shale and sand markers and pore pressure transition zones were consistently within 20-40 ft of the pre-drill predictions and the indicated pore pressure values within 0.2 ppg of pre-drill predictions, according to the authors.

After drilling out the 13 3/8-in., the pressure integrity test confirmed the accuracy of the fracture gradient prediction. Using water based mud, the well was drilled through the prospective reservoir targets to TD.

FATIGUE, SLIP CRUSHING

Authors of IADC/SPE paper 74488 focus on 2 potential problems. "Advanced Fatigue and Slip Crushing Considerations for Deepwater Drilling," was prepared by M L Payne, BP plc; and U B Sathuvalli and P V Suryanarayana, Blade Energy Partners.

Since most offshore fields are drilled from a single structure, the typical development consists of a vertical well with deviated wells extending to the perimeter of the reservoir. Thus, apart from performing the usual torque and drag evaluations, the designer has to track fatigue accumulated in various drill string components.

A review of oilfield literature reveals 2 basic approaches to model fatigue, the classical cumulative damage type models and the more recent linear elastic fracture mechanics (LEFM) models. These studies however are confined to fatigue caused by rotation in doglegs.

While it is recognized that drill string dynamics cause significant fatigue damage, especially in drill collars and BHA components, their effect is not rigorously quantifiable, according to the authors.

By using a classical machine design approach, where a joint of drill pipe is

treated as a machine component, it is shown that the fatigue life of steel drill pipe can be predicted with reasonable accuracy even in the absence of actual S-N curve data, the authors report.

The second problem discussed by the authors occurs during the design of landing strings designed to run long and heavy casing or liner strings.

At these heavy loads, the handling equipment at the rotary table must be chosen carefully. Slip mechanisms that work well in most instances could lead to bi-axial loading that can reduce the axial load rating of the landing string.

The current understanding of slip crushing phenomena is based on a model proposed in 1959 and tests done in 1962. The authors examine recent tests in the light of more advanced models and present an improved understanding of slip crushing loads

AVOIDING DP PROBLEMS

Many Dynamically Positioned (DP) rigs that have begun operation in the past several years have been plagued by station-keeping difficulties.

The authors of IADC/SPE paper 74504, "Avoiding Catastrophes in Dynamic Positioning—Integrating Key Parameters Using a Systems Approach," detail DP operating experience. **L C Wein-garth, West Hou Inc.**, prepared the paper for the Conference.

The author illustrates DP operation successes and failures with case studies of 5 drilling rigs. Each of these cases demonstrates the interdependence of critical equipment and systems that allow a rig to maintain position.

UPGRADE DECISIONS

In IADC/SPE paper 74505, "Design for Semisubmersible Deepwater Development Drilling Unit Conversions is Achieved by Careful Listening," author **A Quintero, Atwood Oceanics Inc.**, outlines the process of deciding which upgrades to undertake.

In 2000, Atwood was in the process of planning an upgrade to the Atwood Eagle from its existing 2,000-3,300-ft water depth rating to 5,000 ft of water. To prepare the upgrade specifications Atwood met with clients and sent a client survey to 9 companies.

Atwood also researched published specifications of competing units. The data were split into two classes of rigs: 3,500-4,000-ft water depth rating and 4,500-5,500-ft water depth rating.

Items reviewed included general particulars, mooring systems, lifting, drilling equipment and mud system. From the research, Atwood developed specifications for a mid-spec rig in each of these categories.

EMERGENCY DISCONNECT

IADC/SPE alternate paper 74506, "Improved Techniques for Simulating the Emergency Disconnect Sequence of a Drilling Riser," describes a transient coupled analysis tool for calculating drift-off of a dynamically-positioned vessel and the associated effect on the emergency disconnect sequence for a drilling riser. The paper was prepared by **M A Wishahy and J N Brekke, GlobalSantaFe Corp.**

The authors report that the drift trajectory has been calculated in the time-domain, taking into account the vessel's change of heading under the influence of current, wind, and waves.

The effect of vessel rotation on horizontal motion is important in calculating the yellow and red alert offsets for an emergency disconnect sequence. Also, the effect of riser restoring force on the vessel is significant.

The authors compare quasi-static analysis results to transient analysis results, showing large variation in riser shape and corresponding offsets, especially in deep water.

The estimation of the yellow and red alert offsets using transient coupled analysis is more accurate, according to the authors.

INNOVATIONS IN P&A

The need has arisen for a new generation of tools specifically designed to meet the demands of ultra deepwater drilling operations.

A primary focus of the development effort for such tools must be to speed up the operation and reduce the number of trips required to complete it.

IADC/SPE alternate paper 74519, "Innovations in Deepwater Plug and Abandonment Technology," was prepared for

Deepwater P&A innovations

A high-pressure underwater external casing patch

A new cut and pull system featuring a single trip hydraulic casing cutter and retrieval spear combination

Modifications to mechanical external latch systems for subsea wellheads

the Drilling Conference by **J W Fisher and K Campbell, Weatherford International Inc.** Among the new tools that have been developed most recently, or are in the late stages of development, are:

- A high-pressure underwater external casing patch;
- A new cut and pull system featuring a single trip hydraulic casing cutter and retrieval spear combination;
- Modifications to mechanical external latch systems for subsea wellheads.

PROSPECT EVALUATION

In IADC/SPE alternate paper 74489, "Evaluation of Deep Water Drilling Prospects Using New Concepts to Identify, Quantify and Mitigate (IQM) Risks for Well Design," author **F R Holasek, Diamond Offshore Team Solutions Inc.**, presents key steps in prospect evaluation.

The overview outlines the evaluation of a drilling prospect to produce a unique set of drilling characteristics and well design for a proposed well.

This unique analysis allows quantitative comparison of drilling parameters such as shallow flow potential, overburden profile, pore pressure profile, fracture gradient profile, and penetration rate profile. This new concept has its roots based in the fundamentals of micro-basin fluid migration gradients and reservoir seal capacity limits.

Once the analysis of the key wells has been prepared, a detailed 2-way time-depth correlation is made from the key wells to the proposed well.

Using this detailed correlation along with micro-basin fluid migration gradients and reservoir seal capacity limits, the drilling parameters can be projected to the proposed well bore, according to the author. ■