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DRILLING CONTRACTOR ANTHOLOGY SERIES

DC MANAGED PRESSURE DRILLING

DC Managed Pressure Drilling
1st Edition

ISBN: 978-0-9906220-9-3

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Preface

By Mike Killalea, IADC Group Vice President/Publisher

Managed pressure drilling, or MPD as it is more commonly called, is steadily gaining acceptance as the means to — with apologies to "Man of La Mancha" —"drill the undrillable well."

The IADC Underbalanced Operations and Managed Pressure Drilling Committee devised this comprehensive definition for MPD:

Managed pressure drilling (MPD) is an adaptive drilling process used to precisely control the annular pressure profile throughout the wellbore. The objectives are to ascertain the downhole pressure environment limits and to manage the annular hydraulic pressure profile accordingly. It is the intention of MPD to avoid continuous influx of formation fluids to the surface. Any influx incidental to the operation will be safely contained using an appropriate process.

Essentially, MPD is a closed-loop drilling system, an approach that facilitates much tighter control of downhole fluid properties. To drill successfully, fluid densities must be such that drilling pressures are below the formation "fracture gradient" but greater than the "pore pressure gradient." When the fracture gradient is exceeded, the rock will fracture. If drilling pressure drops beneath the pore pressure, formation fluids can flow into the wellbore, another undesirable result.

Unfortunately, in many fickle formations, the fracture and pore-pressure curves lie very near one another. This makes drilling navigation tricky and in conventional open-loop drilling, results in many extra casing points. The excessive casing required results in extreme telescoping at TD, such that the final producing string is extremely small — hardly optimal for large production volumes.

Thanks to greater precision control available through MPD techniques, the tricky fracture/pore-pressure window can be negotiated more readily, avoiding these extra casing strings.

Further, more precise control of downhole operations also improve well control.

Many believe that MPD will be the industry standard within five years.

This anthology of MPD articles from IADC's official magazine *Drilling Contractor* examines recent initiatives of the IADC UBO & MPD Committee, as well as important technical articles and case studies from around the world.

Please enjoy these fine articles. For more on the IADC UBO & MPD Committee, go to:

http://www.iadc.org/ubo-mpd-committee/

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MOONPOOL DANCE ON THE PACIFIC SANTA ANA: SUBSEA MUDLIFT DRILLING SYSTEM DEPLOYMENTS PAVE PATH TO DEEPWATER DGD

Lessons gained, improvements made in GOM project as system moves toward commercial launch

By Frédéric Jacquemin, Pacific Drilling, and Dale Straub, Chevron

Figure 1: The Pacific Santa Ana arrived in the Gulf of Mexico in May 2012, set with the mission to launch the world's first commercial dual-gradient drilling system using Subsea MudLift Drilling (SMD) technology.

To paraphrase Van Morrison, it's a marvelous night for a moonpool dance.

The Pacific Santa Ana is the world's first purpose-built, dual-gradient drilling (DGD) rig. Delivered from the Samsung Heavy Industries shipyard in December 2011, it arrived in the Gulf of Mexico in May 2012 with a mission to deploy the first commercial DGD system using Subsea MudLift Drilling (SMD) technology. This article describes the SMD kit and its deployment in the US Gulf of Mexico, and outlines the ways in which the technology can be used to enable exploration of drilling frontiers.

IADC classification

IADC defines managed pressure drilling (MPD) as "an adaptive drilling process used to precisely control the annular pressure profile throughout the wellbore. The objectives are to ascertain the downhole pressure environment limits and to manage the annular hydraulic pressure

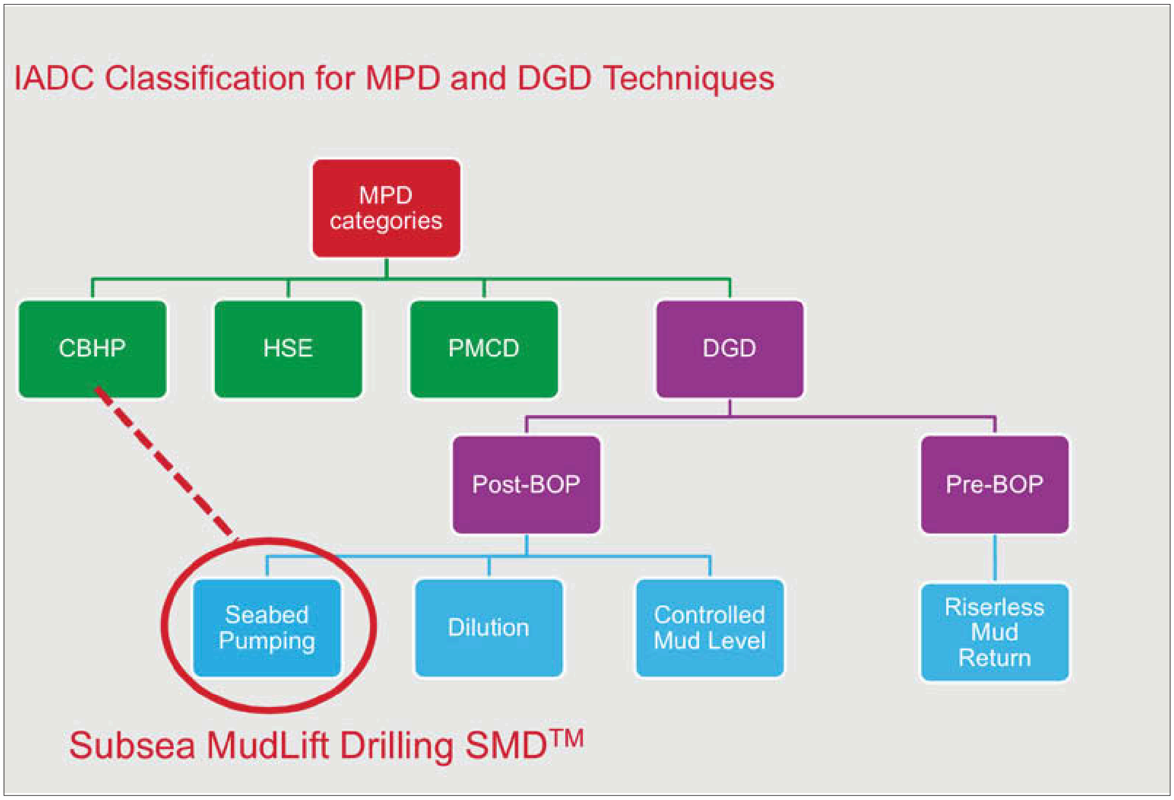

Figure 2 : IADC has classified the various MPD and DGD techniques into different categories. Chevron's Subsea MudLift Drilling is classified under the DGD/Seabed Pumping method but also can be used to perform constant bottomhole pressure MPD.

profile accordingly." The industry recognizes four MPD methods: the most commonly used constant bottomhole pressure (CBHP); health safety and environment, or return flow control; pressurized mud cap drilling or alternative floating mud cap drilling; and DGD.

IADC defines DGD as "two or more pressure gradients within selected well sections to manage the well pressure profile." Different ways to achieve a DGD system include a seabed pumping method, a dilution-based method (with solids, liquids or gases), a controlled mud level method, or simply a riserless mud return solution.

Value propositions

Operators select a particular MPD technique for various reasons. MPD allows for better detection of, reaction to and control of kicks, which also should be smaller in an MPD scenario. Other drivers for using the technology include the virtual elimination of lost circulation due to ballooning formations; typically more efficient cement jobs and fewer squeeze jobs; more predictable well duration outcomes; and a significant reduction in hidden downtime leading to improved reliability.

In deepwater, DGD brings additional value, such as the ability to restore a full riser margin; a reduction by design in the number of casing strings; reduced casing pressure loads; and new completion options since the well arrives in the reservoir with a bigger diameter.

SMD technology

The Chevron SMD technology is most commonly categorized as a seabed pumping method of DGD. It was developed with the objective to allow drilling a narrow-margin deepwater well with a full dual-gradient mud column, with seawater density above the mud line and heavy mud below the mud line. However, Chevron quickly realized this kit could also be used to maintain CBHP in either dual-gradient or single-gradient mode, and in a manner where annular friction pressure can be either trapped or pumped off.

The MudLift Pump (MLP) is the heart of the SMD system. It is located near the seabed, right above the BOP and lower marine riser package (LMRP) assembly. Made of six 80-gal chambers and powered by filtered seawater coming from the rig through a 6-in. ID riser auxiliary line, the MLP pumps mud back to the rig through another 6-in ID mud return line.

The solids processing unit (SPU) is another primary component and sits above the MLP. It sizes the well cuttings to no more than 1.5 in. before they enter the MLP. The subsea rotating device (SRD) provides isolation and pressure differential from below or above, depending on its configuration (single-gradient or dual-gradient mode).

More than one tool in the toolbox

The SMD kit can be used for several purposes, either in dual-gradient or single-gradient mode. In all three examples discussed below, the SMD kit is deployed in 4,000 ft of water and the bit is at 20,000 ft true vertical depth.

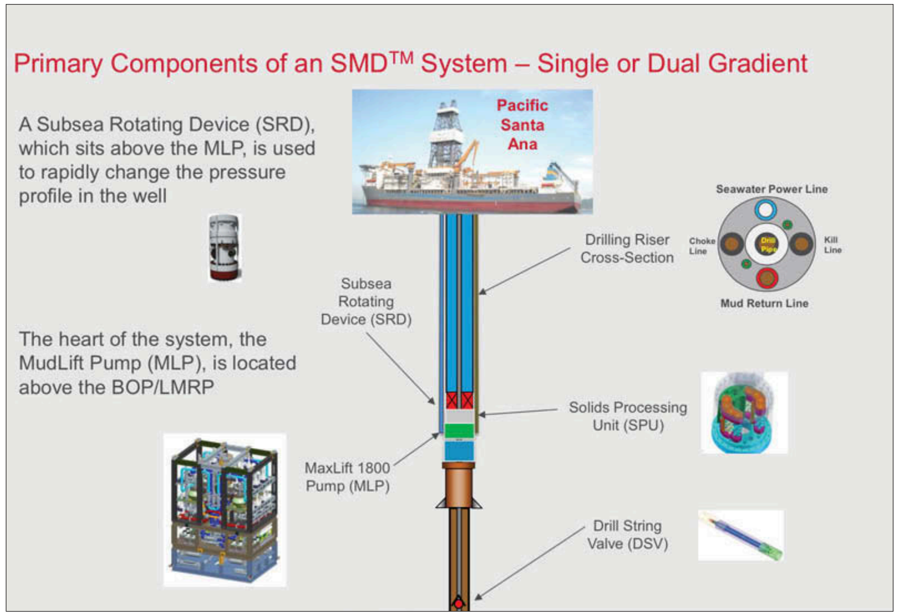

Figure 3 shows the primary components of the Subsea MudLift Drilling (SMD) kit.

In the dual-gradient configuration (Figure 4), the riser is full with 8.6-ppg density riser fluid and a 16-ppg mud system below the mud line. This configuration reaches a bottomhole pressure (BHP) of 15,152 psi, which is equivalent at the bit to a single-gradient mud weight of approximately 14.6 ppg, while navigating much more easily through the drilling window. In this configuration, the MLP inlet pressure in static conditions is 1,840 psi. The MLP inlet can be set at 2,140 psi and trap 300 psi in static conditions, which can then be released progressively to maintain constant BHP while circulating.

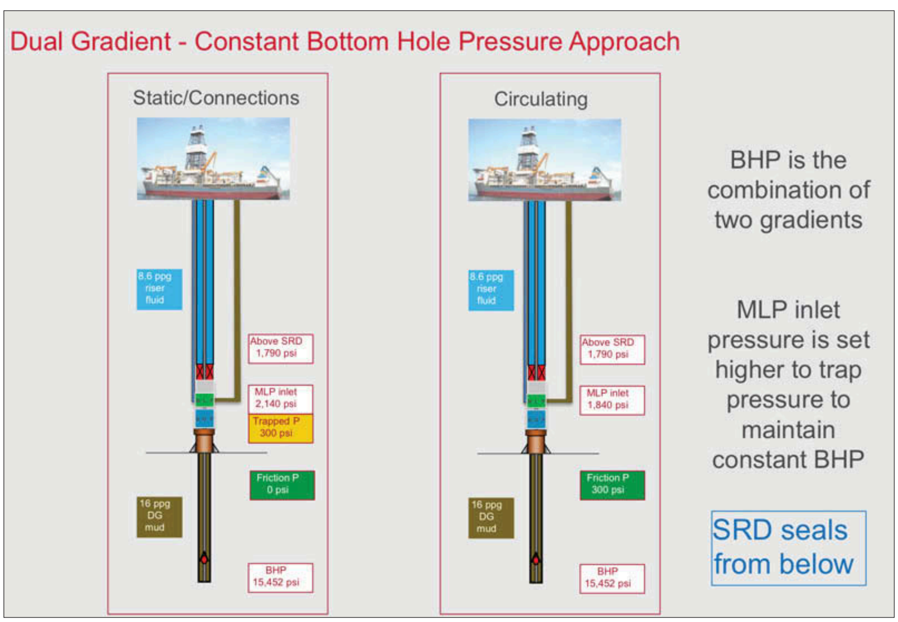

Figure 4 : The dual gradient-constant bottomhole pressure approach uses BHP to combine two gradients. MLP inlet pressure can be set to trap pressure to maintain constant BHP. This configuration is ideal for following steep pressure gradients in narrow-margin deepwater fields, following natural pressure profiles.

In the single-gradient configuration (Figure 5), a static BHP of 15,183 psi is reached with a single 14.6-ppg mud column. The MLP inlet is set at 3,336 psi to trap 300 psi and maintain constant BHP while circulating.

This method is similar to conventional CBHP methods and useful to navigate through narrow pore pressure margins that can be reached with a single mud gradient.

In both approaches, a CBHP philosophy is used. Additionally, in both instances, the pressure below the SRD exceeds the pressure above the SRD, which therefore needs to be designed to seal from below.

The third configuration (Figure 6) also uses a single mud gradient but uses the MLP to pump off annular friction pressure (AFP) while circulating. This configuration is ideal in pressure regression zones when trying to maintain a low, near-constant BHP while circulating. In this instance, Chevron designed the amount of AFP pumped off while circulating to ensure the well would never become underbalanced in the event of a pump failure. In this configuration, however, the pressure above the SRD exceeds the pressure below the SRD, which was therefore designed to seal from above.

The moonpool dance

Once fully assembled, the SMD kit cannot be run all in one operation with the LMRP and BOP. Instead, the lower BOP must be run first on drill pipe and then followed by the LMRP-MLP-SPU-SRD-riser running assembly. It is quite a dance; we call it the moonpool dance.

The MLP was loaded onboard the Pacific Santa Ana in June 2013, and the SMD kit has since been deployed four times.

The SMD system is not fully commercial yet and is in the final stage of obtaining regulatory and class approval, but each deployment leads to incremental lessons learned, further objectives demonstrated and experience accumulated. Chevron, Pacific Drilling, Enhanced Drilling and GE Oil & Gas crews jointly developed procedures to ensure smooth execution of the moonpool dance, with significant attention paid to planning and safety. Using the model of "Verify, Inform, Consult, Accountable, and Responsible," matrices were developed to help identify roles and responsibilities.

The successes for the team to date are numerous. Through the deployments, the team has accomplished every major objective on the path from a prototype toward a fully operational system that may be used in a normal deepwater drilling environment. Nearly every component and sub-system has been deeply analyzed and frequently improved, and members of the team have grown significantly in their operational and diagnostic competence with the system. Equally important, the system is beginning to demonstrate unparalleled control of wellbore pressure and promises to address many of the pressure challenges typically seen in deepwater wells.

During the latest deepwater deployment, the SMD team worked through a comprehensive set of assurance tests drawn from requirements of the local regulatory agency, a third-party certified verification authority, and Chevron. The system worked well mechanically, and almost every test requirement was completed as planned. Most significantly, a well control test with a simulated kick demonstrated that the system

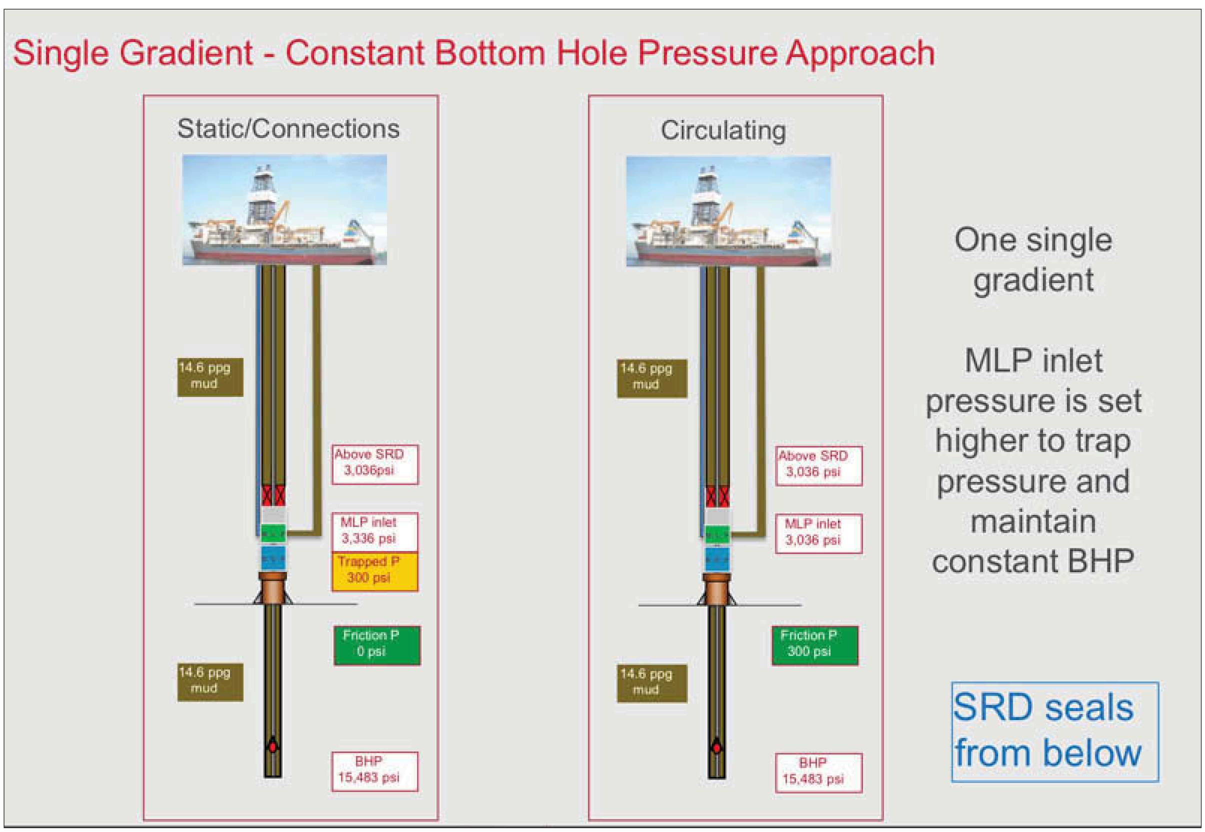

Figure 4 : The dual gradient-constant bottomhole pressure approach uses BHP to combine two gradients. MLP inlet pressure can be set to trap pressure to maintain constant BHP. This configuration is ideal for following steep pressure gradients in narrow-margin deepwater fields, following natural pressure profiles.

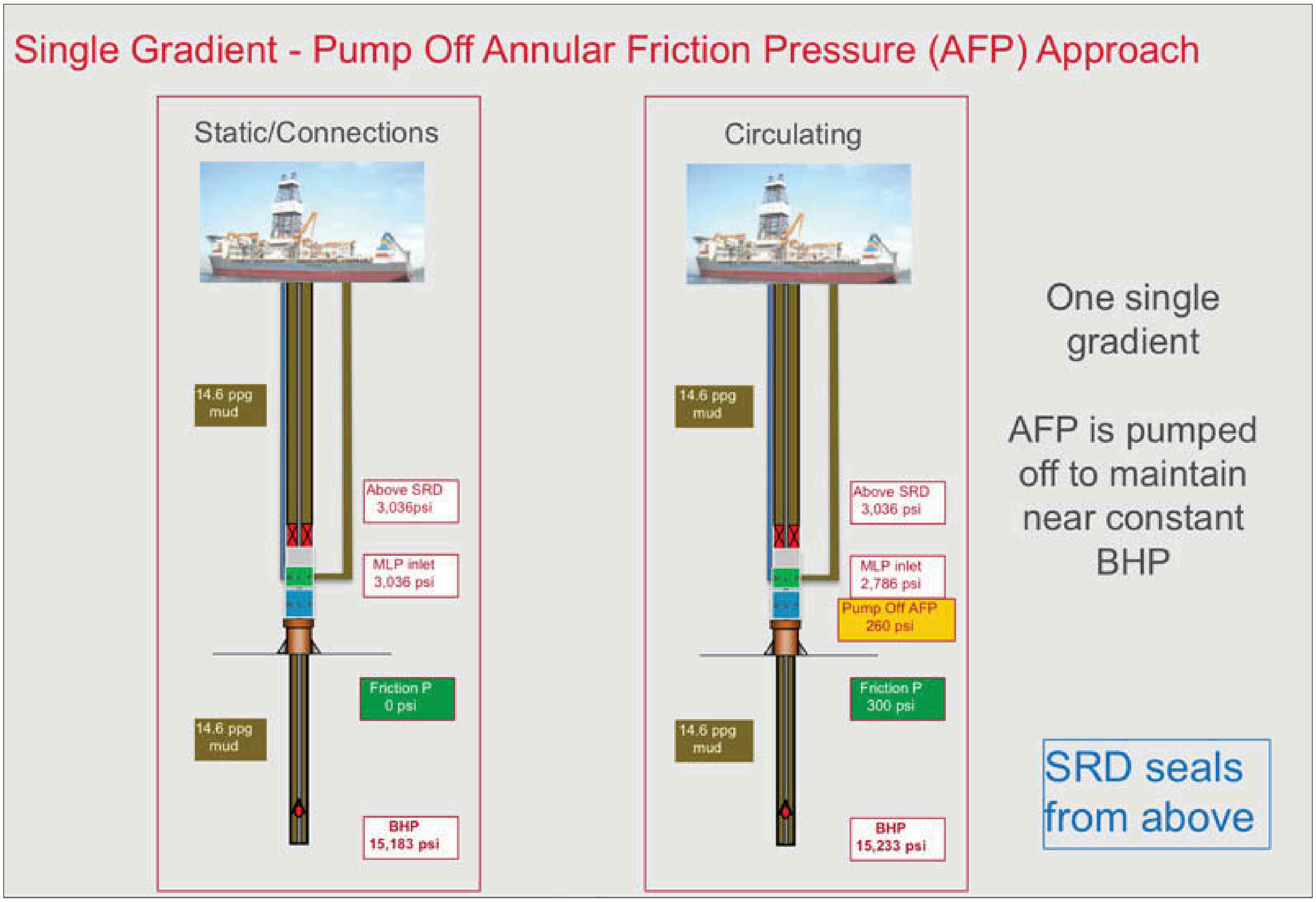

Figure 6: The single gradient-pump off AFP approach pumps AFP to maintain near-constant BHP. It is ideal in pressure regression zones.

is not only capable of supporting the detection of small influxes but these may be detected significantly sooner than in a conventional deepwater drilling operation.

However, there are a few remaining issues that must be fully resolved before Chevron can consider the system ready for open-hole operations. The system is operating on an extended deepwater soak test to further validate pressure integrity under extended subsea conditions.

In summary, there are multiple MPD and DGD techniques, each with different modus operandi and value propositions for a particular well challenge. Successfully deploying the world's first SMD kit with the Pacific Santa Ana in the Gulf of Mexico was not the end of the journey but the beginning of a revolutionary tool. Finally, integrating new technology goes beyond proving new equipment; it is at least as much about writing and proving new processes and training the right people.

Can I just have one more moonpool dance with you, my love?

Subsea MudLift Drilling (SMD) is a trademark of Chevron.

This article is based on a presentation at the 2015 IADC/SPE Managed Pressure Drilling and Underbalanced Operations Conference, 13-14 April, Dubai.

Reprinted from the May/June 2015 issue of Drilling Contractor.

MPD POISED FOR GROWTH IN AUSTRALASIA DEEPWATER

By Shaun Toralde and Chad Wuest, Weatherford

The pace and success of Australasia's deepwater exploration and development depends on achieving high standards of safety and environmental stewardship while addressing operational and efficiency challenges. The solution will come in part from lessons learned globally and locally with managed pressure drilling (MPD) systems and methodologies.

Global success with MPD systems, along with pioneering deepwater MPD efforts in Indonesia and onshore success in Australia, New Zealand and Papua New Guinea (PNG), provide a firm base of experience and technology for this next step in regional drilling practices. The volume of work under way in the region and the capabilities of MPD systems and methods to enhance these operations suggest the technology is poised to have a significant impact on deepwater drilling in the area.

Weatherford's Model 7875 BTR RCD is helping to extend MPD capabilities to deepwater drilling operations from dynamically positioned drilling vessels.

MPD deepwater technology

MPD systems have had remarkable success enabling safe and efficient operations in a range of land and offshore applications. Within a closed-loop system, MPD methodologies provide a means of listening to the wellbore and quickly adjusting to micro-oscillations in downhole pressure. This measurement and control of wellbore pressure has been a solution to many difficult well problems, particularly in deepwater.

Within an MPD system, a small set of equipment makes up a scalable kit. The system begins with the inherent safety benefits of installing a rotating control device (RCD), which diverts fluids and gas away from the rig floor. Precise pressure monitoring and fingerprinting improves wellbore visibility that informs manual controls for early kick detection. A full MPD Microflux control system provides wellbore visibility plus pressure control via an automated, specially instrumented choke manifold.

The extension of MPD to deepwater applications aboard dynamically positioned rigs occurred with Weatherford's development of a subsea RCD that is integral to the marine riser system. The Model 7875 below-tension-ring (BTR) RCD extends MPD methodologies to deepwater drilling.

Implementing MPD aboard a drillship or semisubmersible extends new layers of well control barriers through capabilities such as early identification and mitigation of gas influxes. Specific to deepwater operations, it also provides a solution to riser gas. By preventing it at the source, MPD stops gas from coming out of solution in the riser where it is above the seafloor BOP stack.

The first applications of BTR RCD technology occurred aboard a drillship targeting carbonate prospects in Indonesia. Using pressurized mud cap drilling (PMCD) methodologies to drill in total loss circulation conditions has allowed operations to reach zones that were impossible to drill conventionally.

Australasia MPD

MPD systems have been used onshore in Australia, New Zealand and PNG for nearly a decade. Some of the earliest applications have been in PNG's prolific fractured carbonate reservoirs and fields in the lowland areas of the country. Most MPD applications