Deepest Managed Pressure Drilling (MPD) HPHT well drilled in Offshore Malaysia with @balance Services

THE CHALLENGE

- The operator decided to explore deeper hydrocarbons in sands under HPHT conditions with minimal petrophysical information
- Uncertainties due to high pressure ramps and weak sands increased the challenge to reach TD of the section

THE SOLUTION

- Enhance operational safety by converting the wellbore to a closed-loop automated Managed Pressure Drilling (MPD) circulating system
- Perform real-time bottomhole pressure (BHP) management using an automated MPD system, the Dynamic Annular Pressure Control (DAPC) system by @balance Services
- Identify pressure ramps early by performing Dynamic Flow Checks (DFCs) and dynamic Formation Integrity Tests (FITs)
- Identify and control wellbore breathing to maintain required BHP

THE RESULTS

- @balance Services used MPD to identify weaker formations below the shoe which defined the true upper limit of the drilling envelope. This was done by conducting dynamic FITs and leak-off tests at regular intervals and after drilling through any suspected weak zone, such as sand.
- @balance Services identified wellbore breathing and dynamic FITs/DFCs were controlled within limits to minimize their effect

DAPC system installed at cantilever deck

Data Limitation in HPHT Reservoir Section

This well was the second well drilled in the two-well HPHT campaign in 2012. The well was spudded on May 7th, 2012 and plugged back on November 5th, 2012. For the HPHT section, there was no data available from any of the surrounding wells that could assist in modeling the pore pressure and fracture gradient as inputs for well design. @balance Services proposed MPD to map the pore pressure and fracture gradient to identify the safest operating window during the drilling phase.

THE RESULTS (cont'd)

- Drilled deeper than planned and delivered the deepest HPHT well in Malaysia to date
- Penetrated huge gas-bearing discoveries
- MPD technology has become a pertinent application for HPHT exploration wells in the area

Identify the Upper Limit (Fracture Gradient)

@balance Services performed three dynamic FITs for TTD-1. Figure 1 below shows one example: the dynamic FIT was executed with 17.5 ppg mud flowing at 380 gpm while increasing surface backpressure to 500 psi to reach an estimated mud weight of 19.1 ppg. The flow-out reading confirmed a four barrel loss during the dynamic FIT. After the dynamic FIT confirmed an expanded upper limit, it was decided to increase the mud weight to 17.8 ppg as drilling continued down the 8½-in section to the target depth of 4,830 m-MDDF as the maximum safe drilling window.

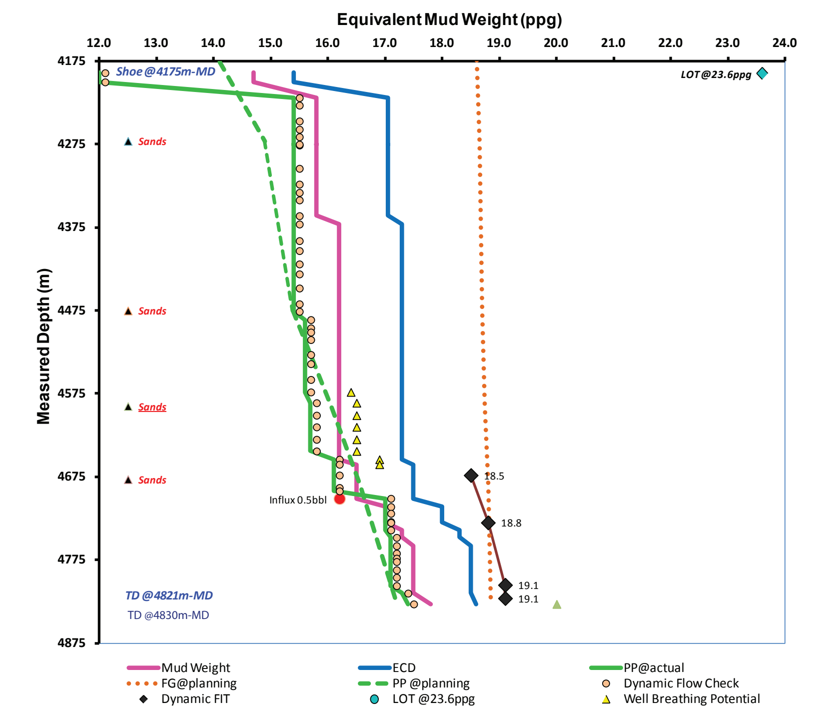

Figure 1: Map the safest operating window using automated MPD

Identify the Lower Limit (Pore Pressure)

@balance Services mapped out the lower limit (pore pressure) by using a DFC process with MPD in conjunction with other pore pressure prediction methods. Constant BHP was maintained during the drilling process by applying a backpressure of up to 800 psi during connections in order to compensate for the annular friction losses while circulating and drilling. This minimized the risk of wellbore breathing as well as the risk of taking a high intensity kick when the pumps were switched off. When there was a need to flow check the well, the backpressure was reduced gradually in stages of 100-200 psi. If the well started to flow, the backpressure was immediately increased to minimize the influx volume, while ramping down the rig pumps prior to shutting in the BOP. A total of 56 DFCs were necessary in order to reach well TD without uncontrolled influx incidents.

Identify and Control Wellbore Breathing/Ballooning

Wellbore breathing and formation supercharging, if wrongly interpreted, could easily be identified as a kick and handled incorrectly. The primary strategy by @balance Services to minimize wellbore breathing was to maintain a required BHP with MPD. It was more challenging because of the DFCs required to fingerprint the pore pressure. When DFCs were performed, the BHP was reduced by the amount of backpressure applied at the surface. As a compromise, it was decided to limit the amount of backpressure reduction if there was any sign of ballooning, i.e., if the backpressure was reduced to a preset amount but not all the way to zero.

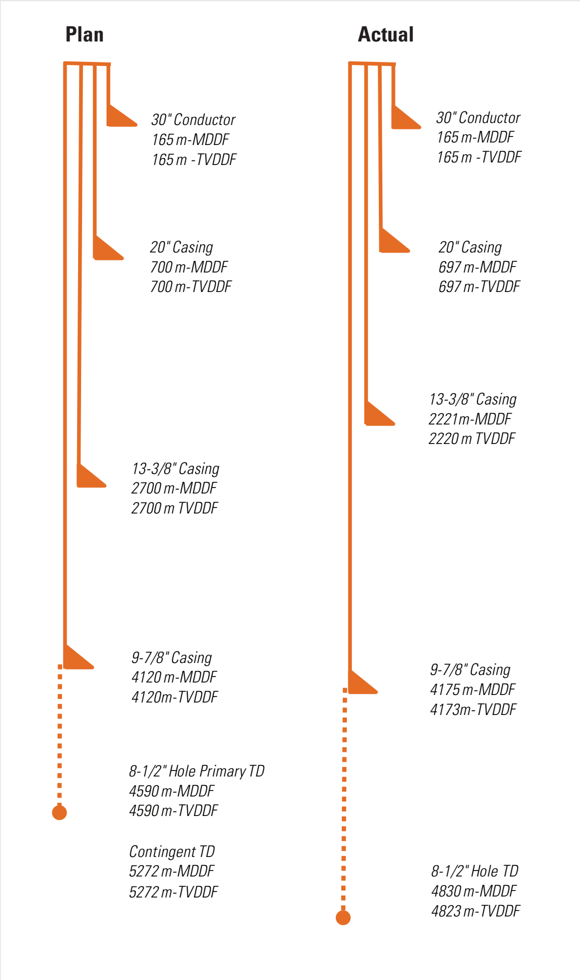

Figure 2: Well plan versus the actual drilled

HOLD RCD installed above annular BOP

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