Case study: Offshore Brazil

DYNAFLOW system successfully drills pre-salt well without losses, saves $1.08M USD in rig costs

A major operator planned the first phase of an extensive drilling campaign in a deepwater reservoir located approximately 185 km (115 miles) off the coast of Brazil in water depths of approximately 2,050 m (6,725 ft).

Reservoirs in the area are characterized by pre-salt, heterogeneous carbonate/lacustrine rocks at a total depth of approximately 6,000 m (19,685 ft) from sea level. The operator planned to drill a well with five sections using water-based drilling fluids. Baker Hughes worked to develop an integrated drilling solutions for the customer.

Due to reservoir pressures, the reactivity of the formation, and environmental regulations regarding fluid disposal, the operation required a fluid system that guaranteed well integrity and stability in the high pressure window, minimized lost circulation, and ensured full environmental compliance.

As part of an integrated drilling program, Baker Hughes recommended its DYNAFLOW™ reservoir drill-in fluid (DIF). This divalent brine-based DIF is a stable, gum-free system designed to minimize rock/fluid interactions and maintain well integrity and wellbore stability. It also minimizes lost-circulation risk; extends the driller's operational pressure window; and reduces the environmental footprint associated with fluid interfaces, transportation, and discharge.

Collaborating on the optimal fluid formulation

This proposed drilling operation marked the first DYNAFLOW application in Brazil. As a result, Baker Hughes conducted extensive laboratory tests at its Houston Technology Center to design the optimal system formulation to meet operational requirements. Using input from the operator, the Drilling and Completion Fluids (DCF) team evaluated the DYNAFLOW fluid in three-day, dynamic aging tests that simulated bottomhole temperature of 212°F (100°C). The fluid demonstrated excellent rheology behavior in these tests. It also possessed good lubricity properties, with a measured coefficient of friction of 0.15.

Based on the anticipated reservoir characteristics, the team designed the fluid with a density of 13.2 ppg (1.58 sg). While calcium bromide was initially considered as a base brine, high costs and environmental concerns prompted the DCF team to use calcium chloride ($CaCl_2$) coupled with the Baker Hughes MIL-CARB™ calcium carbonate additive to weight up the brine to the required density. This pushed the DYNAFLOW system to the limit as high rheological properties could arise from excessive solids, posing a high risk of wellbore instability and differential sticking.

The team also developed the Baker Hughes ADVANCESEAL™ AS lost circulation material (LCM). This single-sack LCM was specially designed to mitigate lost circulation and prevent formation damage during reservoir drilling.

In lab testing, the DYNAFLOW fluid demonstrated a rheology profile that implied excellent clean up performance in the well. It also demonstrated an ability to equally suspend larger-diameter cuttings and much

Challenges

- Effectively drill an ultra-deepwater well at 2,050 m (6,725 ft) water depth
- Deliver wellbore through a pre-salt, heterogeneous reservoir without loss of well integrity or lost circulation
- Develop and effectively deliver a drill-in fluid solution with high solids loading but no environmental impact

Results

- Delivered an integrated drilling solution including:
  - DYNAFLOW DIF
  - Dynamus™ extended-life drill bit
  - Advanced LWD and MWD services (OnTrak™ LWD, StarTrak™ LWD, MagTrak™ LWD, CoPilot™ dynamics)
- Successfully drilled the well with zero environmental impact related to transportation and discharge
- Minimized lost circulation events thanks to optimal drilling fluids solids design
- Delivered a high-integrity wellbore thanks to low ECD impact
- Conducted wireline logging without any issues related to water-based fluids with high solids content
- Maintained fluid stability during 10.5-day logging operation, with no sag issues
- Avoided the need for recirculating during logging operations, saving approximately two days of rig time and $1.08 million USD

smaller weighting agents for proper sag management. In viscometer testing, the formulation measured a sag factor of less than 0.51, indicating a strong fluid structure and minimal sag concerns.

Particle size distribution testing supported that the fluid possessed the optimal solids design to minimize operational time and help achieve the customer's goals of:

- Reduced lost circulation risks
- Guaranteed well integrity
- Minimal to no formation damage.

Efficiently drilling a stable wellbore

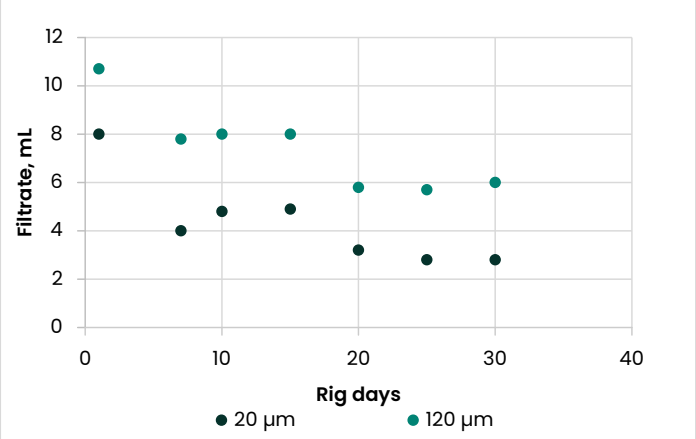
The DCF team formulated the DYNAFLOW DIF with the required volumes of $CaCl_2$ brine and MIL-CARB additive to achieve the desired 13.1-ppg (1.57 sg) mud weight and provide effective formation bridging. The team introduced the DIF formulation to drill the last section of the well, an 8½-in. section with a maximum 1° inclination. The DYNAFLOW fluid maintained the required density and stability to successfully drill the interval.

The fluid demonstrated excellent compatibility with the reservoir formation with minimal-to-no formation damage observed while drilling. Filtration tests on 20µm, and 120µm ceramic filter disks demonstrated excellent filtration control and extremely low filtration rates despite the system's high solids content.

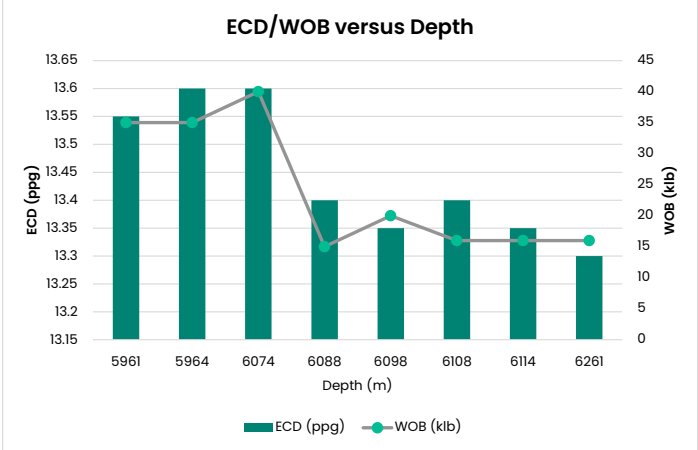
Baker Hughes team members from across the various drilling disciplines worked closely to maintain precise control of the drilling parameters and manage the DYNAFLOW fluid properties. As a result, the DYNAFLOW system provided good control of the equivalent circulating density to avoid formation damage or fluid losses.

The DYNAFLOW DIF remained stable under static condition throughout the 10.5-day logging operation, with no sag issues. While previous experience with other DIFs indicated a need to recirculate the fluid every three to four days to avoid sag or other stability problems, the DYNAFLOW system eliminated this need—saving the operator approximately two days of rig time and an estimated $1.08 million USD.

The success of this first DYNAFLOW system drilling operation in Brazil proved the DIF's ability to deliver a stable wellbore in a challenging deepwater well—with minimal time, cost, and environmental impacts. Baker Hughes is taking the lessons learned from this well to further refine its fluid systems for greater performance gains in other complex offshore projects.



In filtration tests performed over a 30-day period during the drilling operation, DYNAFLOW DIF demonstrated excellent filtration control.



DYNAFLOW DIF provided excellent controls on ECD at different WOBs while drilling the section.

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