GeoBalance® Optimized Pressure Drilling Services

TWO TECHNOLOGIES. ONE SOLUTION.

UNDERBALANCED AND MANAGED PRESSURE DRILLING SYSTEMS
# GEOBALANCE® OPTIMIZED PRESSURE DRILLING SERVICES

Customized Managed Pressure Drilling (MPD) and Underbalanced Drilling (UBD) Systems

<table>
<thead>
<tr>
<th>Goal</th>
<th>Challenge</th>
<th>Solution</th>
<th>GeoBalance® Optimized Pressure Drilling Services</th>
<th>Related Halliburton Services</th>
</tr>
</thead>
<tbody>
<tr>
<td>Improve Project</td>
<td>Escalating rig rates High equipment costs High material costs</td>
<td>Reduce number of drilling days Reduce casing strings to target Reduce mud costs Start production while drilling Reduce actual AFE by reduction of nonproductive time (NPT), and/or selling produced hydrocarbons</td>
<td>GeoBalance MPD service GeoBalance UBD service</td>
<td>Sperry</td>
</tr>
<tr>
<td>Economics</td>
<td></td>
<td></td>
<td></td>
<td>Pressure-While-Drilling™ wellbore pressure measurement service</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Mercury™ electromagnetic telemetry service</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Remote Operations Centers</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>ADT® drilling optimization service</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>– Wellbore integrity</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>– Hydraulics management</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>– Drilling integrity</td>
</tr>
<tr>
<td>Drill the Undrillable</td>
<td>Depleted zones Lost circulation Narrow pressure margins Differential sticking Access to bypassed reserves High-pressure/high-temperature (HPHT)</td>
<td>Maintain constant bottomhole pressure Control pressure profile with critical margins: - Lower limit: Pore or collapse pressures - Upper limit: Fracture pressures</td>
<td>GeoBalance MPD and UBD automated services: Automatic choke SENTRY™ control software Advanced data monitoring and acquisition system</td>
<td>Baroid</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GeoBalance MPD optimized service: ADT® drilling optimization services – Wellbore integrity – Hydraulics management – Drilling integrity</td>
<td>Optimized drilling fluid systems</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>GeoBalance MPD Sigma® service: Comprehensive pressure management Nitrogen injection system Separation system</td>
<td>Optimized corrosion program</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>Chemical plug with timed dissolution</td>
</tr>
<tr>
<td>Optimize Drilling</td>
<td>Ensure wellbore integrity Navigate through critical pressure boundaries Optimize drillstring performance and life Avoid kicks/losses Improve rate of penetration</td>
<td>Pre-planning to determine pressure limits Advanced data monitoring and acquisition system Dynamic data modeling and control Expert interpretation Reduce time on drilling the overburden Drill faster in high-compressive rock formations</td>
<td>Front-End Engineering Design GeoBalance MPD and UBD Automated Service GeoBalance MPD Optimized Service: ADT® drilling optimization services – Wellbore integrity – Hydraulics management – Drilling integrity</td>
<td>Landmark</td>
</tr>
<tr>
<td>Performance</td>
<td></td>
<td></td>
<td>GeoBalance MPD and UBD Self-managed service: RCD 5000™ rotating control device Manual choke</td>
<td>Drillworks® software Real Time Operations Center™ facilities</td>
</tr>
<tr>
<td>Improve Reservoir</td>
<td>Accurate reservoir characterization while drilling Increased recovery rate Fracture identification Zonal isolation</td>
<td>Minimize skin effect Stay below formation pressure Ongoing well testing while drilling</td>
<td>GeoBalance UBD Service Nitrogen membranes Compression equipment Separation equipment</td>
<td>Project management Reservoir engineering and geological services</td>
</tr>
<tr>
<td>Performance</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Operational Excellence</td>
<td>Safely and efficiently handle hydrocarbons</td>
<td>Trained/qualified personnel Coordinated operations Highest safety and service quality standards</td>
<td>Comprehensive project management Engineering and supervision onsite and through Real Time Centers™ Hazard identification Hazard and operability studies</td>
<td></td>
</tr>
</tbody>
</table>
OPTIMIZED PRESSURE DRILLING SERVICES

When you are facing complex pressure regimes that make conventional drilling impossible, the GeoBalance® optimized pressure drilling solutions can help you achieve well objectives while reducing overall time and cost.

GeoBalance services comprise the industry's most comprehensive suite of pressure optimization solutions for well construction and reservoir challenges in critical pressure environments:

» GeoBalance Managed Pressure Drilling (MPD) service overcomes drilling challenges such as deepwater, subsalt wells, narrow pressure margins, and lost circulation zones. By maintaining a minimal overbalance pressure that reduces formation impact while preventing instability, GeoBalance MPD service provides precise control of annular pressure for penetrating zones not drillable with conventional methods.

» GeoBalance Underbalanced Drilling (UBD) service provides a unique well-testing-while-drilling capability that can reduce the time and cost of reservoir characterization and vastly improve production. Tailored to your application, GeoBalance UBD service delivers critical drilling benefits, too – improving performance while enabling you to safely drill through reservoir rock with minimal to no formation damage.

Model, Measure, Optimize

Our approach is "model, measure, optimize." We bring together the right combination from a vast array of technologies that predict, perform, and analyze to ensure a cost-effective custom solution for safely achieving your objectives. GeoBalance optimized pressure drilling solutions deliver what you need – whether that involves a full UBD program, an MPD program, or both.

OBJECTIVE: IMPROVE PROJECT ECONOMICS

Nonproductive time (NPT) due to kicks, mud losses and differential sticking, loss of wellbore, and need for a side track – all these problems cause project costs to soar. And what about borehole instability? Long periods of rig downtime, special rig equipment, extra casing strings, and large volumes of drilling fluids are consumed trying to control unstable zones. Unstable holes are difficult to clean, liable to stuck pipe, and makes it difficult to complete and to run pipe and casing. Again, costs increase.
GeoBalance optimized pressure drilling solutions can improve the bottom line. By maintaining optimal bottomhole pressure (BHP), GeoBalance techniques deliver improved wellbore quality and can reduce the high costs of drilling wells by mitigating lost circulation, kicks and differential sticking while drilling within narrow pressure margins.

We will help you choose the right approach, and then customize your solution – whether it is a single GeoBalance service or a totally integrated package that brings together the downhole technologies of our Halliburton brands:

» Sperry Drilling offers the most advanced drilling and formation-evaluation-while-drilling tools, along with a range of auxiliary equipment.

» Baroid provides specialty fluid designs for non-damaging fluids that provide easy cleanup for reinjection and improve separation operations, chemical barriers, corrosion systems and solids management. Baroid also offers chemical barriers, corrosion systems, and solids management.

» Landmark has advanced digital solutions that provide a platform for seamless integration of data throughout the process, as well as geomechanical modeling for pore, collapse, and fracture pressure prediction.

What’s more, we have the resources in place to deliver comprehensive project management over the life of your project. From the start, complete front-end engineering design (FEED) capabilities provide services that facilitate proper candidate well selection and reservoir evaluation, with follow-through to onsite engineering and execution.

Integrated into a custom solution to achieve the specific objectives of your project, GeoBalance optimized pressure drilling services combine to maximize operational efficiency and prevent problems to deliver maximum return on your investment.

Central to our philosophy of operational excellence, the Halliburton InSite® database provides the platform for integrating a constant stream of while-drilling data from both surface and downhole tools and sensors. This enables key personnel to have immediate access to the full breadth of critical well information.

**InSite® Rig Information System: Powerful Integration**

Fully integrated for use with the InSite system, SENTRY™ data acquisition and control software makes use of several communications protocols.
to provide the underlying GeoBalance control system. In addition to performing hydraulics calculations and accommodating manually entered inputs to be stored in the InSite system, the SENTRY system is closely linked to data validation and event detection modules.

With the InSite system, drilling parameters are measured, recorded, and displayed at the wellsite, and all data can be transmitted to operation control experts in one of our global Real Time Centers™ (RTCs). Data analysis can then be performed at the rigsite, remotely in the customer’s office, or in Halliburton visualization rooms, with results available worldwide via the InSite Anywhere® Internet link service.

With this strategic integration of expertise, technology, and processes, only Halliburton gives you a complete one-stop solution through our fully engineered GeoBalance optimized pressure drilling services.

**Well Candidate Selection for Underbalanced Drilling and Managed Pressure Drilling. Which solution is right for you?**

Both underbalanced drilling and managed pressure drilling can provide solutions to your specific reservoir and drilling challenges, adding tremendous value in improved overall project success. Both techniques provide the means of controlling downhole pressures during drilling, but they differ significantly in how they do it, making proper candidate selection an important factor in success:

» Based on the main objectives identified at the start of the project, the selection process consists of first analyzing geomechanical and petrophysical information to determine whether or not a particular well and/or reservoir is a potential candidate for UBD or MPD.

» Once a prospect is identified, the optimal drilling technique is selected and any potential production improvement is evaluated. Different scenarios are modeled, and the results are used in both detailed wellbore hydraulics flow modeling and economics evaluation.

» Final candidate qualification depends on an economic evaluation that establishes cost differences between these drilling methods, and compares these against other technologies, such as stimulation, with their potential results.

» To achieve optimal value, a candidate might require MPD in the upper-hole section, while the reservoir section might require being drilled underbalanced.
Halliburton can help with initial candidate well evaluation, providing a candidate selection tool and economics/risk analysis software for both qualitatively and quantitatively evaluating the benefits and limitations of each technique.

OBJECTIVE: DRILL THE UNDRILLABLE

MPD Solutions for Enhanced Well Construction

Often, as reservoirs mature, new reserves prove to be economically or mechanically inaccessible using conventional methods. Depletion of reservoirs and narrow pressure margins in zones overlying the new target create insurmountable barriers to new reserves. And NPT can threaten project viability.

GeoBalance Managed Pressure Drilling services overcome these barriers to quickly get you through trouble zones and into the pay.

By maintaining a minimal overbalanced annular pressure that reduces formation impact, MPD provides total control of exact annular pressure for penetrating zones not drillable with conventional methods.

With the GeoBalance MPD service, you “drill the undrillable.” Capable of drilling narrow pressure margins efficiently and safely, MPD can minimize differential sticking and lost circulation, reduce the number of casing strings required to access the target, and improve drilling economics through fast rates of penetration (ROPs) and longer bit life.

GeoBalance MPD Service Benefits

» Reduce NPT
» Reduce fluid loss and associated costs
» Improve well control; ideal for kick control
» Minimize differential sticking
» Reduce damage to sensitive formations
» Improve efficiencies in hard rock, mature reservoirs
» Tackle high-pressure and high-temperature reservoirs
OBJECTIVE: OPTIMIZE DRILLING PERFORMANCE

The Right MPD Solution at the Right Service Level
Because different levels of reservoir complexity require different solutions, GeoBalance MPD is offered at various service levels to meet specific project needs. The basic self-managed MPD service, for example, may require only a rotating control device (RCD) with a manual choke providing surface pressure control. The next level of MPD uses an automated choke system to provide precise BHP control. At the automated MPD service level, the SENTRY system, with guidance from the GB Setpoint™ hydraulics simulator, provides remote-controlled choke management requiring limited onsite personnel.

For maximum value, the optimized GeoBalance service combines its automated MPD capabilities with ADT® drilling optimization services to achieve optimum pressure regimes and to control BHP in real time from the wellsite or from an RTC.

Through the process of “model, measure, and optimize,” our highly skilled and experienced optimization service engineers employ a suite of real-time-enabled software applications, along with surface and downhole measurements to generate predrill models, which then are verified and updated with actual measurements during drilling. Analysis of any differences can identify and preempt potential problems, eliminating NPT and improving efficiency.

The optimized GeoBalance MPD service addresses vital drilling functions in three key disciplines:

**Hydraulics Management** – Combines pressure-while-drilling (PWD) data with surface monitoring and real-time forward-modeling to manage wellbore pressures. It also addresses hole cleaning efficiency by using predictive software analysis of annular pressures from downhole tools, and by comparing predicted with actual torque-and-drag trends.

**Drillstring Integrity** – Focuses on eliminating excessive forces on the drilling assembly by modeling the natural frequencies of the drilling assembly to avoid resonant conditions, measuring shock and vibrations, identifying any active vibration mechanism, and supplying the right corrective actions to eliminate drilling vibration.
Wellbore Integrity – Determines critical wellbore pressure boundaries by using tools such as the GeoTap® formation pressure tester or pore pressure calculations from log responses. Pore pressure is determined both predrill and in real time, by using wellbore stability software to calculate the collapse pressure of the wellbore. Several models are used to determine fracture pressures to calculate the pressure operating window.

Safety First
To complete the optimized GeoBalance MPD service, the system is equipped with the Event Detection System (EDS) to recognize and warn of event anomalies. With kick detection and lost circulation as a minimal level of event detection, the EDS uses advanced flow modeling and metering for automatic flow monitoring that rapidly and accurately identifies any influx or loss, and then sends an alarm to the operator, along with a suggestion for controlling the event. If an alarm is not acknowledged in a timely manner, the EDS drives the chokes to a safe position and sounds an audible alarm.

OBJECTIVE: IMPROVE RESERVOIR PERFORMANCE

UBD Solutions for Rejuvenating Mature Reservoirs
Today, more and more operators are seeing the value of UBD from increased production rates and ultimate recoveries. As an added value, in some cases, the production during drilling has paid for the UBD services. Using the GeoBalance UBD service to meet specific reservoir challenges can improve overall success and add tremendous value over the life of your project. Penetration rates increase, fluid loss and differential sticking are reduced, and reservoir production is improved. In some cases, zones that may have been unproductive with overbalanced drilling have proven to be viable reservoir pay with UBD. Mature reservoirs have been rejuvenated in many instances with underbalanced drilling.

Increase Efficiency and Reduce Formation Damage
Providing comprehensive reservoir characterization while drilling, the GeoBalance UBD service can help reduce time and cost associated with conventional methods of gathering and analyzing well test data. Describing and evaluating each geologic zone immediately after it is penetrated while still drilling gives personnel the flexibility to adjust a drilling program “on the fly.” And reduced formation damage helps ensure that the characterization accurately describes the reservoir.
SIGMA® SERVICE: THE BEST OF BOTH WORLDS

Two Technologies. One Solution.
Multiphase Systems for MPD and UBD
When low formation pressures necessitate using a two-phase fluid – such as foam, mist, or a gasified fluid – to lower the bottomhole annular pressure, the GeoBalance Sigma® service provides the upstream injection system and downstream separation system needed for safely handling a gaseous medium.

To deliver the right solution for your well, the Sigma service draws from a complete line of feed compressors, nitrogen membrane units, injection control manifolds, mist pumps, boosters, and separators designed to accommodate multiphase systems for both MPD and UBD applications.

At the Sigma service level, the GeoBalance service techniques and equipment can effectively control BHP throughout the entire range – from underbalanced, to balanced, to overbalanced drilling – and maintain optimized pressure control through narrow margins.

Whether you need the drilling advantages of managed pressure drilling or the enhanced production of underbalanced drilling – or both – Sigma service helps ensure that you are equipped with the right multiphase system for a GeoBalance solution that will give you complete control.

Safe. Effective. Reliable. The Complete Equipment
Lineup from Halliburton
GeoBalance optimized pressure drilling services provide critical BHP control in a safe, pressurized closed-loop system of equipment combinations for your specific application. And as your single-source supplier, Halliburton offers the full lineup of modular components for a complete surface equipment package:

Upstream
» Liquid nitrogen
» Natural gas compression
» Air compression and membrane nitrogen equipment

Downhole
» PWD sensors
» Nonreturn valves (NRVs)
» Telemetry systems
Over the past 20 years, Halliburton has conducted GeoBalance® UBD and MPD services in 28 countries, drilling more than 1500 wells to date.

**Downstream**
- Rig-assist snubbing units
- Rotating control devices
- Separation systems
- Solids control equipment
- High-pressure cuttings sampling units
- Metering systems
- Data acquisition system

Based on your objectives, system design setups can range from simple wellhead RCDs to complete, “all-of-the-above” equipment packages.

Across the entire spectrum, safety is the key consideration in assuring that each equipment setup controls the operation within strict safety limits. And because equipment is sourced in-house from Halliburton, guaranteed a consistent, high-quality, and reliable supply of this equipment.

We can provide it all.

**OBJECTIVE: ENSURE OPERATIONAL EXCELLENCE**

Today, new techniques from Halliburton offer safe, reliable reservoir and well construction solutions to help improve the drilling process and to enhance asset value. Just as important as the equipment and services we provide, you will find that safety is a critical measure of operational excellence at Halliburton.

Incorporating our philosophy of “model, measure, and optimize,” GeoBalance optimized pressure drilling services bring together the systems you need for enhanced well construction and reservoir solutions.

In addition, our comprehensive project management capabilities, from FEED through production evaluation, give you a reliable single-source provider for equipment, materials, and trained personnel. With ISO 9001 and ASME certifications, our equipment and processes are documented to help ensure the highest quality and safety standards across the board.

Perhaps the single largest benefit of the GeoBalance optimized pressure drilling solutions is how safe these techniques are. Combined with Halliburton management systems and health, safety, and environment (HSE) policies and practices, which are competently implemented by experienced personnel, the GeoBalance services bring you effective pressure optimization solutions with a track record of HSE excellence.
Sales of Halliburton products and services will be in accord solely with the terms and conditions contained in the contract between Halliburton and the customer that is applicable to the sale.

H012708
© 10/17 Halliburton. All Rights Reserved.