@balance Services

Managed pressure and underbalanced drilling solutions
M-I SWACO, a Schlumberger company, is an industry leader in engineered solutions for managed pressure drilling (MPD) and underbalanced drilling (UBD), delivered through the comprehensive resources and expertise of its @balance Services. @balance Services looks at every aspect of a drilling project to assess the expected conditions and risks. It then aligns the specific objectives of the project with components from a technology portfolio that ranges from a suite of high- and low-pressure rotating control devices (RCD) and drilling pressure controls to kick detection, fluid separation and nitrogen gas services. Supported by sophisticated engineering software tools, @balance Services has everything it takes to prevent, detect and mitigate potential well control risks during drilling, and optimize wellbore stability and productivity. Onshore or offshore, @balance Services has the technologies and capabilities to design and deliver project-specific solutions that combine fit-for-purpose control systems with pressure control equipment and fluid expertise to effectively manage the downhole pressure barrier and meet operators’ drilling, economic, and HSE objectives.
Safely getting the most from the well

Features
- Engineered approach to MPD/UBD applications
- Comprehensive suite of rotating control devices
- Advanced pressure control technologies
- Automated and manually controlled chokes
- Kick detection services
- Fluid separation services
- Nitrogen gas services
- Customized solutions
- Proprietary engineering software

Benefits
- Reduced well control incidents
- Minimized NPT
- Enhanced wellbore stability
- Identification and mitigation of potential risks
- Improved safety
- Reduced cost

@balance Services combines the advanced MPD and UBD technologies and services with know-how to identify and prevent risks associated with unstable boreholes, uncertain pressure regimes and narrow pressure windows.

For customers this means optimum safety and increased levels of pressure control that maximize performance while reducing costs and non productive time (NPT).

What separates @balance Services from other providers is its extensive range of cost-effective MPD and UBD services and products, which include:

- Engineering services:
  An engineered approach to planning and executing MPD and UBD operations that assesses the possible risks to deliver project-specific solutions that support customers’ objectives.

- Rotating control device services:
  The portfolio includes a broad range of high- and low-pressure RCDs for fluid containment, stand-alone pressure management, and full-service MPD and UBD operations on land and offshore.

- Drilling pressure control products:
  Proactive and reactive pressure control products comprising a wide selection of chokes and manifolds with stand-alone manual or automated dynamic controls.

- Kick detection services:
  Using accurate, real-time flow data to identify early small volumes of influx and losses and sound the appropriate alarms.

- Fluid separation services:
  A wide range of equipment for the separation, recovery, and management of drilling fluids and solids, including multiphase separation, gas flow measurements, hazardous gas removal, venting, and flaring.

- Nitrogen gas services:
  Nitrogen generation and injection using trailer-mounted or stackable skid units, data acquisition, engineering plans for multiphase operations, emergency shutdown and alarms, backpressure control manifolds and sample catchers.
A comprehensive engineered approach to project planning and management considers specific project objectives in a methodical risk assessment that includes model-based analysis, job planning and execution, and pressure performance evaluation.

This risk and needs evaluation begins with understanding operators’ drilling goals and the targeted downhole environment with respect to pressure limits, profile uncertainties, and prior experience with losses, gains, instability, and other pressure-related NPT incidents. On the basis of these engineered assessments, fit-for-purpose equipment recommendations are proposed to minimize the risks.

In developing an in-depth and engineered solution, @balance Services builds on understanding the specific needs and risks to analyze the various drilling scenarios of a project. In turn, this allows expert drilling engineers to determine the optimum pressure limits, fluid hydraulics, and mud weights necessary to form the fully engineered basis for the job plan. The plan includes the required degree of control, the subsequent equipment it will need, the drilling and pressure control procedures, contingencies, and any necessary rig crew training.

The comprehensive plan also includes:
- Equipment configuration and installation
- Surface and downhole pressure and flow rate objectives
- Hazard identification
- Contingency responses
- Regulatory compliance actions

Once developed, the plan is used to maintain annular pressure within specified wellbore pressure limits; optimize circulating pressure, hole cleaning, and trip time; and maximize ROP without exceeding mud weight windows.
Keeping pressures in line

The most thoroughly devised plan is only as good as the project execution, which is where @balance Services takes center stage. Throughout the drilling operation, office-based and wellsite engineering support is provided with the sole focus of executing the drilling plan to meet the outlined objectives, ensure on-time delivery, mobilize and manage any additional technical resources that may be required, and do so in full compliance with all HSE and regulatory policies.

In addition, during drilling the MPD/UBD team has at its disposal advanced engineering software including the proprietary M-I SWACO VIRTUAL HYDRAULICS® and PRESSPRO RT® monitoring packages that help ensure safe operating guidelines and deliver a stable wellbore. While-drilling support also extends to the global network of Schlumberger drilling and petrotechnical experts and, where required, can include the establishment of communication between the rig and these experts for the delivery of real-time solutions to particular drilling challenges.

The job does not end with the completion of the well. In keeping with a commitment to Excellence in Execution, after every job @balance Services engineers routinely conduct a post-well analysis to evaluate the service performance relative to the planned objectives, degree of control, and reliability. This allows customers to quantify the value delivered and supports continuous improvement in pressure control product delivery.
RCDs are critical components for any MPD/UBD operation, but given today’s increasingly demanding drilling conditions they have taken on even more importance. @balance Services is at the forefront in engineering continuous improvements in sealing element materials and designs, certification testing consistent with API RP 16 RCD guidelines, operational efficiency and safety, through-bore capacity, and spillage containment.

The result of that effort is a comprehensive range of RCD services that includes some of the industry’s most widely used high- and low-pressure units.

**High-pressure RCD services**

High-pressure applications include constant bottomhole pressure MPD, single- and multiphase UBD, pressurized mudcap drilling, environmental protection and exploration drilling. These challenging applications have established field-proven RCD acceptance for use in deepwater, shale gas, HPHT, fractured carbonate, deep tight gas, subsalt, and horizontal developments.

The range of high-pressure RCDs is outfitted with unique bearing and sealing element features for use on land and offshore rigs that facilitate sealing element replacement and clamping.

High-pressure RCD services include remotely operated seal clamps, customized low-pressure containment risers, integrated sealed-bearing assemblies, and in-house sealing element testing with customer drilling fluids. Low-profile designs are available to accommodate rigs with limited space below the drill floor.
Low-pressure RCD services
@balance Services low-pressure RCDs have a long history of robust performance and dependable seal integrity during flow drilling operations, under hazardous conditions, and for influx control. Low-pressure RCDs are available with compact profiles, making them ideally suited for large- and small-diameter well sections on rigs with limited space between the wellhead and the rig floor. The sturdy design and efficient profiles of the low-pressure RCDs minimize the need for continuous onsite service support, making them particularly suitable for onshore drilling rigs in remote areas. Low-pressure RCDs from @balance Services have been used widely in onshore applications such as the Bakken, Eagle Ford, Haynesville, Marcellus, and Niobrara shale plays as well as the Permian Basin oil and gas fields and the deep gas fields of South Texas and Louisiana.

RCD sealing elements that optimize seal integrity
M-I SWACO offers a choice of sealing elements to optimize seal integrity for a range of drilling fluid types and high-temperature conditions, including geothermal applications. Sealing element assemblies can be configured with either one or two elements to accommodate different sizes of drill pipe and casing as well as kelly types.
Industry-leading M-I SWACO technologies provide @balance Services with an unsurpassed ability to control pressures during the most demanding MPD and UBD operations. With the DYNAMIC ANNULAR PRESSURE CONTROL (DAPC) system, chokes, and separators, @balance Services routinely optimizes pressure management to promote safe and efficient drilling. Pressure control performance has been proven in severely depleted onshore and deepwater reservoirs, high-angle multiphase MPD and UBD wells, horizontal shale gas wells, HPHT and geothermal reservoirs, and while drilling with casing, cementing, and closed-loop pressure control with wired drill pipe.

The @balance Services MPD and UBD drilling pressure control solutions include manual reactive control and fully automated, model-based, dynamic control. The degree of control required for each well is determined, and then a tailored control solution is developed for specific applications. When an application calls for reactive control during unanticipated pressure or flow changes, manually operated or semi-automated digital control consoles are provided for one or more stand-alone chokes.

Narrow margin applications that pose a high risk for losses, influx and instability typically call for proactive, automated, dynamic control. Proactive services include the high-speed DAPC unit integrated with a real-time hydraulics model to maintain constant bottomhole pressure during every phase of drilling.

@balance Services offers a wide selection of new generation chokes, including automated gear and piston chokes, the M-I SWACO eCHOKE, high-pressure AUTOCHOKE and the 10K SUPER CHOKE, complemented with small-footprint manifolds rated for high-pressure, high-flow and severe H2S conditions. These high-pressure drilling and well-control chokes are widely recognized for their robust, fast-acting performance and precise flow control at pressures up to 20,000 psi.

Industry-leading control systems
The benchmark DAPC unit and the novel M-I SWACO LOW-PRESSURE AUTOCHOKE CONSOLE (LPAC) provide unprecedented levels of control in MPD and UBD applications. The DAPC system has evolved as a standard for automated MPD. It is the first to incorporate a real-time hydraulics model capable of simultaneously controlling multiple chokes and a backpressure pump to provide a singular level of field-proven performance, accuracy, and response.

The M-I SWACO LPAC unit is a unique, easy-to-use, and simple-to-install digital console with a touch-screen human machine interface that provides precise pressure control in MPD and UBD operations.
Leveraging the M-I SWACO premier position in fluids and related technologies, @balance Services offers a wide range of services, equipment, and expertise for the separation, recovery, and management of drilling fluids and solids. The suite of solutions includes two-, three-, and four-phase separation; geological sample catching; hazardous gas removal; and gas flow measurement, venting, and flaring.

The @balance Services engineered approach first assesses anticipated conditions and then selects fit-for-purpose separation services to provide risk-mitigating solutions tailored to optimize safety and efficiency. Onshore and offshore separation services can be configured for conventional, MPD, UBD and well-control operations on conventional, coiled tubing and workover rigs.

Fluid separation equipment is available for high fluid volumes as well as service in H2S, corrosive oxygen and other hazardous gas environments. In addition, compact multi-service units are available for total gas containment and integrated pressure and fluid management.

Equipment planning, installation, operation, maintenance, and hands-on training and skills development for operator and rig personnel are also provided.

The fluid separation services are some of the most technically advanced and cost-effective solutions on the market, including:

- **Multiphase fluid separators**
  Fluid separation services include skid-mounted, vertical, and horizontal vessels designed to separate and vent large volumes of free gas from returning fluids and solids. The line of separators includes adjustable onshore and compact offshore units, and unique high-capacity units capable of pressurized operation.

- **CARBONTRACKER gas-flow meter**
  The evolutionary M-I SWACO CARBONTRACKER† gas-flow meter is an ultrasonic flow meter capable of accurately detecting gas at low and high flow rates. It measures gas velocity, pressure, and temperature for determining volumetric and mass flow rates.

- **Vacuum D-GASSER units**
  M-I SWACO skid-mounted vertical and horizontal vacuum tanks are designed to remove all entrained gases—including H2S and corrosive oxygen—from the returning well fluids. D-GASSER† units include discharge lines to vent freed gas at a safe distance from the rig, while returning restored mud to the active system.

- **TOTAL GAS CONTAINMENT SYSTEM**
  The M-I SWACO TOTAL GAS CONTAINMENT SYSTEM† (TOGA†) is a completely enclosed system designed to safely remove all gases from returning well fluids. It includes a two-phase mud/gas separator and vacuum D-GASSER unit that can be configured to accommodate virtually any drilling operation.
A safe and cost-effective MPD or UBD drilling operation often hinges on detecting even small volumes of fluid influx and losses early in the well construction process.

@balance Services provides a precise Coriolis flow-meter for accurate kick detection and rapid well control response solutions during MPD operations. The kick detection services continuously record flow in and out of the well and calculate delta flow, which is used as an early indicator of influx, kicks and losses.

In a typical configuration, the Coriolis flow-meter is installed downstream of the MPD choke manifold where it monitors the flow rate of the returning fluid.

When a backpressure pump is used during MPD operations to augment the annulus pressure, the injected drilling fluid will circulate through the choke manifold and Coriolis flow-meter, which provides active kick detection when the rig pump is off.

Used in conjunction with the DAPC system, flow-out data from the Coriolis flow-meter is fed directly to the pressure controller to eliminate delays. The human/machine interface in the DAPC system monitors and tracks the delta flow and issues alarms when it exceeds programmed limits.

The early influx and loss detection capability of the @balance Services kick detection services has been used in real-time flow tests and dynamic leak-off tests to establish critical operating pressure limits.

Timely flow-based kick detection services
Recognizing the growing use of MPD and UBD for protecting and developing conventional and unconventional oil and gas resources, @balance Services has developed efficient and innovative nitrogen gas flow drilling solutions. Two configurations of nitrogen gas equipment are available: integrated trailer-mounted and stackable skid-mounted units.

The mobile, trailer-mounted nitrogen generation unit (MNGU) is easy to transport, has a small footprint, and requires minimal rig-up and rig-down time, making it an ideal solution for onshore UBD applications. Built for extreme arctic and desert climates, the skid-mounted nitrogen generation unit (SNGU) can be driven with either diesel or electric motors to provide high-volume nitrogen injection. Trailer- and skid-mounted units can be combined to inject incremental volumes of nitrogen at precise rates.

**Engineered, project-specific N₂ solutions**

Engineering services include injection system planning, multiphase flow modeling and analysis, model calibration while drilling, data acquisition, emergency shutdown and alarm systems, choke manifolds, sample catchers, multiphase fluid separators, gas meters, and flare stacks.

In one multi-well onshore project, @balance Services designed a concentric casing N₂ injection system and associated drilling programs for high-angle wells in deep, highly fractured and severely depleted carbonate reservoirs. This solution effectively protected the reservoirs by reducing the hydrostatic pressure to very low levels, which was controlled effectively within a narrow margin. The approach allowed the operator to drill ahead with MWD and LWD, achieving real-time directional control and reservoir evaluation.
Global experience

Put @balance Services to work for you
To find out more about the wide range of @balance Services for MPD and UBD applications, and benefits delivered to customers around the world, contact your local M-I SWACO representative.
Gulf of Mexico: MPD solution effectively improves drilling efficiency in mature offshore field

The Situation
An operator planned to re-develop a mature and highly depleted field where the last two sidetrack wells were drilled some 8 to 10 years earlier. These offset wells encountered several difficulties associated with depletion, reduced fracture gradient, wellbore instability and high, unmanageable equivalent circulating densities (ECD). Consequently, there was no conventional way to reduce ECD and maintain a constant bottomhole pressure (CBHP) in the small margin between fracture gradient and pore pressure to prevent annular loading and packoff, stuck pipe, gas influx, and heavy losses.

The Solution
To avoid a repeat of the difficulties experienced in the offset wells, @balance Services suggested automated managed pressure drilling (MPD) as the best solution for controlling ECD and CBHP to allow the operator to safely meet its target. Given the uncertainty surrounding the pore pressure in its target sand, an MPD system was considered a viable option for confirming pore pressure at a critical point in the well.

The Results
The operator employed automated MPD technology in its first slot recovery well, where the system drilled 1,800 ft (549 m) of 8 ½-in. hole, effectively managing the BHP in windows ranging from ± 0.16 lb/gal while drilling, ± 0.12 lb/gal while tripping, and ± 0.05 lb/gal while rolling over the mud from 14.8 to 15.0 lb/gal (1.7-1.8 sg). By controlling BHP and ECD with automated MPD, the operator was able to reach its planned targets trouble-free and in significantly less time than would have been possible with a conventional approach. Thanks to the use of MPD services, the operator also avoided wellbore instability and well-control events that had occurred frequently in the offset wells.
Online Resources

@balance Services
www.miswaco.com/atbalance

Underbalanced and Managed Pressure Drilling (UBD/MPD)
www.miswaco.com/mpd

Pressure Control Products
www.miswaco.com/pressurecontrol