New technology enhances UBD success, hints toward integration

By Ted Wilkes, Weatherford

FROM THE DAYS of air-compression techniques to the newly discovered potential for offshore operations, underbalanced drilling (UBD) has come a long way in 50 years. More than ever, operators are taking advantage of UBD techniques to increase production and reduce costs over the life of a well. Industry estimates forecast that UBD operations may double within the next 5 years.

The advantages of UBD (the ability to drill with a borehole pressure that is lower than formation pressure) make the technique a necessity for successful operations in wells with traditional challenges to production. Until recently, the dramatic increase in horizontal drilling operations has been the driving force for UBD advances, mainly because horizontal wells harbor great potential for formation damage, resulting from drilling fluids that remain in contact with the productive interval for long periods. However, newly developed tools and practices are allowing operators to apply the benefits of UBD to geothermal reservoirs, fluid-sensitive reservoirs, and wells with depleted pressure or lost circulation.

UBD ADVANTAGES

By drilling with underbalanced pressure, operators prevent invasion from drill solids, fines, and drilling muds that can damage pore throats and permeability needed for hydrocarbon transit.

Unlike overbalanced drilling techniques, UBD service requires a "softer touch" in the wellbore, and the specialized equipment and techniques that allow this process can incur higher initial costs. However, over the long term, UBD continues to supply numerous economic and production advantages:

• Allows for production while drilling;

• Prevents invasion from drill solids, fines, and drilling muds that can damage pore throats;

• Reduces formation damage through easier cleanup and managed fluid viscosity;

• Allows greater rates of penetration through more efficient removal of cuttings;

• Eliminates lost circulation in thief zones;

• Prevents differential sticking of the drillpipe (i.e., no lost drilling time or rig time caused by tool fishing);

• Requires less weight on bit.

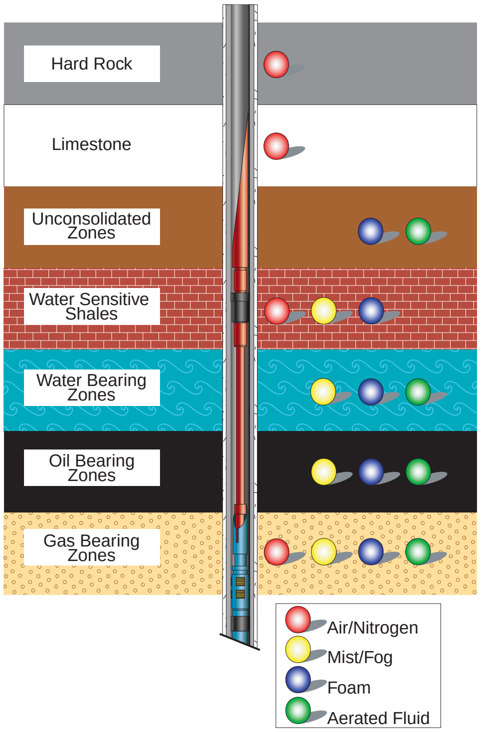

Figure 1: Operators currently use 4 types of UBD drilling fluids: air/nitrogen, mist/fog, aerated fluid and foam.

FROM FAD TO TREND

Initially, UBD products and services were like every other new offering: a piecemeal business that was thoroughly tested but unproven by time. Specialized suppliers and regional service companies were the only devoted UBD providers, treating the process as an alternative to normal drilling rather than a standard practice. Without standardization or long-term, time-tested results, UBD was only profitable at a higher expense.

Now, as an emerging technology, UBD has grown from the single concept of drilling with air (injecting a combination of air and liquid at the surface) into an array of techniques that include drilling with mist, stable foam, or aerated fluids. Until the last 5 years, however, operators have been using these techniques on a relatively limited basis.

TECHNOLOGY

Developing technology is giving service companies and operators an opportunity to address some of the critical areas of UBD operations:

• Proper project design and modeling;

• Fluid system compatibility;

• Guidance systems and motors;

• Well control and surface separation.

PROJECT MODELING

Without dependable modeling, an accurate prediction of critical items such as bottomhole pressure, annular velocity, and hole cleaning is impossible. Previously, an operator's inability to model or simulate flow dynamics accurately has hampered the success of UBD operations.

Recent research programs involving flow loops and full-scale wellbore simulators have unveiled a wealth of rheological data that allows for multiphase models. Using these models to generate a database, researchers are now able to interpolate data and accurately predict crucial dynamics, such as frictional factors and non-homogenous flow regimes. These results are directly applied to each fluid system and additive concentration, providing more refined predictions and, in turn, more successful UBD applications. With new test programs under way, researchers are working to characterize the ability of each type of compressible fluid to power drilling motors, adding to the future arsenal of efficient drilling options.

Other unforeseen benefits can result: Good computer modeling coupled with UBD also allows log analysts and engineers to see zones previously hidden or obscured by overbalanced drilling. The following example underscores the importance of understanding how well geometry and fluid rheology can improve hydraulic calculations.

An operator drills a horizontal well that has a 14,100-ft true measured depth, and an 11,000-ft true vertical depth, then the operator completes the well with 5 1/2-in. casing to 10,700 ft. A 2 7/8-in. American Openhole drillpipe is used to pump 95% nitrogen at 900 scf/min and foam water at 9 gal/min. A bottomhole pressure of 2,100 psi results, and the well has a 3.7-lb/gal equivalent circulating density. The 2,100 psi is the sum of a 300-psi contribution from hydrostatic pressure and an 1,800-psi contribution from friction.

As the example illustrates, friction forces can become dominant, especially in slimhole applications. However, controlling the BHP with friction is difficult, because friction pressure is eliminated the instant that flow ceases. Modeling software has now enabled the industry to anticipate and therefore plan for these types of conditions. We are now able to monitor real-time values and compare them to our planned scenario(s), thereby maintaining the wellbore in a controlled state.

BETTER FLUIDS, REDUCED COSTS

By definition, UBD operations dictate that the borehole pressure must be lower than the formation pressure; therefore, the hydrostatic column of drilling mud used in OBD jobs must be replaced with a column of “lighter” mud. Less dense muds can be achieved with mists, stable foams, and aerated fluids that reduce the BHP. Integrating UBD well servicing with on-site data acquisition enables the tailoring of drilling fluids to increase rates of penetration and cuttings removal, while reducing skin and formation damage.

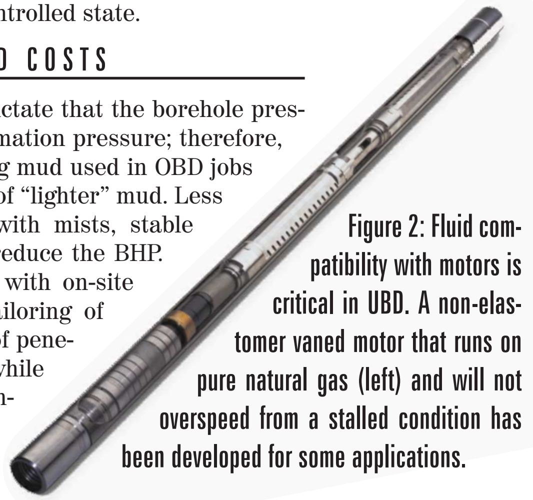

Figure 2: Fluid compatibility with motors is critical in UBD. A non-elastomer vaned motor that runs on pure natural gas (left) and will not overspeed from a stalled condition has been developed for some applications.

Operators currently use 4 types of UBD drilling fluids: air/nitrogen, mist/fog, aerated fluid, and foam (Figure 1).

Operators can “lighten” drilling fluid with nitrogen, but the reluctance comes with the added cost of supplying nitrogen to the wellsite. Advancements in membrane technology make it possible for wellsite personnel to generate nitrogen at high levels of purity. These second-generation membrane units require less initial compression, which reduces cost and spatial requirements. Because space comes at a premium in offshore operations, researchers are building on the membrane technology to develop new compressors and boosters strictly suited to the offshore environment.

Stable foam is another preferred drilling medium because of its ability to carry high volumes of cuttings. A new recyclable foam reduces environmental concerns and disposal costs, while remedying containment problems associated with previous foams. Allowing the use of special additives, foams can work in tandem with shale control polymers and corrosion inhibition systems that can withstand extreme well conditions. The advantages of foam are obvious in the following example.

In West Texas, UBD was used to increase the rate of penetration (ROP). For the first leg of the project, the operator drilled a 12 1/4-in. hole to 1,100 ft and set 9 5/8-in. casing. This top section was drilled with a conventional fluid system. For the bottom section, the operator drilled a 7 7/8-in. hole to 8,000 ft, using foam that was inhibited for shale hydration and corrosion.

The foam was chosen to compensate for several issues: unknown fluid influxes from a saltwater-bearing zone from 3,000 ft to 5,000 ft; massive lost-circulation zones; unknown hole stability or formation competency; and the potential for shale swelling from water contact. Foam also provides superior hole cleaning with low bottomhole pressure to maximize ROP.

Saltwater influx at the rate of 2 bbl/min did not affect drilling performance, and no lost circulation occurred where wells were previously drilled with mud and the addition of 4 tractor trailer loads of lost-circulation material. The operator and contractor set a local drilling record by completing drilling in 68 rotating hours, compared to more than 200 hours on fluid.

In yet another area, foamed fluid is boosting the efficiency of drilling through surveying. Foam allows evaluation of formation fluids while those fluids are co-mingled with the drilling fluid. Sample identification and fluids/solids computer flow monitoring is more accurate. Therefore, operators are experiencing less and less pump and compressor shutdown while drilling, and they are making hole faster. The added benefit is that the enhanced cuttings removal by foam increases the footage per bit ratio before change out. Simply, costs are reduced because drilling is faster and tools last longer.

GUIDANCE SYSTEMS, MOTORS

Fluid compatibility with guidance systems and motors is crucial, because compressible fluids require specialized tools that have been adapted for UBD operations. Steering tools and other downhole instrumentation need protection via hydraulic vibration-dampening subs.

Here are some MWD advances important to UB operations:

• Conventional mud-pulse telemetry (positive or negative) has a limited ability to transmit signals through compressible fluids. Operations have been tailored to facilitate mud-pulse telemetry via parasite strings and concentric coiled tubing, increasing daily cost;

• Improvements in wireline wet-connect systems employing integral float subs have sustained the viability of these systems;

• Other advances are expanding the use of electromagnetic telemetry and guidance systems, allowing operators to reach new depths and surpass previous stratigraphic limitations.

For certain operations, researchers have designed a gas-powered, non-elastomeric vaned motor that runs on straight gas and will not overspeed from a stalled condition (Figure 2).

In one case, a South Texas operator faced a challenging environment when drilling horizontally into an underpressured limestone reservoir at 11,000 ft TVD to create 2,500-ft lateral sections. For drilling medium, the operator used lightweight nitrogen foam, but drilling was still difficult. With the addition of a wet-connect steering tool guidance system, the operator drilled a record-length lateral for that area at that depth.

WELL CONTROL/SURFACE SEPARATION

In UBD operations, well control results from a combination of fluid hydrodynamics, rotating control devices, chokes, and surface separation systems. Since 1994, improvements in existing technology have enhanced the efficiency of UBD techniques, resulting in the following advancements:

- Rotating control heads rated to 5,000 psi static pressure;
- Improved stripping rubber design and composition;
- Surface separation kits rated to 5,000 psi;
- Automated choke systems;
- Surface separation facilities capable of handling high-volume production of liquids, cuttings, and drilling fluids;
- Closed -loop separators capable of handling 20 MM scf/D;
- More efficient and compact separators suitable for offshore use.

High chemical costs can erode a well's profitability, but one new technique solved that problem at Lake Maracaibo, Venezuela, with the first deployment of an offshore closed surface system designed for foam. The project included support from the world's premier, fully equipped coiled tubing drilling barge. With the ability to use foam in a 200-bbl system that was suitable for offshore application, the operator was able to lower circulating densities to the required range of 1.5-3.0 lb/gal. After oil/water separation, the returning foam fluids were recirculated, reducing the fluid costs of make-up chemicals and water required during extended drilling periods.

TREND TOWARD INTEGRATION

As UBD operations begin to embody increasingly complex technology and specialized materials, some operators are reluctant to invest in the necessary training and significant capital expenses, even if UBD techniques will enhance production.

Currently, the industry has focused on a "solutions" trend that encourages providers to develop integrated offerings that cover all facets of UBD work. The expectation is that many operators will turn to service companies for integrated services, just as they have in past years for coiled tubing, fracturing, cementing, and other operations. In this capacity, the service provider serves as a single point of contact for project engineering and service coordination.

While some equipment may be standard to UBD jobs, the UBD service provider has an inventory of equipment (both standard and specialized) suited to a wide range of applications. In an integrated approach, the UDB provider brings this resource to the planning table and helps the operator establish project goals.

Successful integration is not an automatic process; it requires a structured plan that accounts for all of the critical areas of UBD operations. The competitive service provider should possess an understanding of compressible fluid chemistry and behavior and the entire system that delivers and conditions the fluids, as well as the proper application of fluid chemistry to formation and well conditions.

An integrated approach to UBD offers the following benefits:

- Provides a better base of knowledge on industry-leading technologies and practices;
- Eases the process of evaluating "what works best" in a given operator's specific situation;
- Grants ready access to a wide array of support services required for a successful UBD project;
- Can add millions of dollars of value to the remaining life of the well.

CONCLUSION

While UBD operations have increased during the past 50 years, great leaps in technology over the past 5 years have made a significant difference in production and economics. Operators are now examining candidate wells and applications for UBD that would not have been considered a few years ago. Fluid advances are allowing researchers to tailor the drilling medium to the particular well, and at the same time, engineers are refining equipment to broaden their application to traditionally untouchable areas, such as offshore wells.

However, a thorough understanding of UBD technology and the proper application of techniques is crucial to operational success, and more often, operators are turning to service companies for the integrated approach that combines experience and expertise.

ABOUT THE AUTHOR

__Ted M Wilkes__ is the __Weatherford__ Global Product Line Manager for Underbalanced Drilling. He earned his BS degree in petroleum engineering from __Marietta College__ in Marietta, Ohio. Most recently, Wilkes was a partner with __Clearwater Inc__, the parent company of __ECD Northwest__, a leading provider of underbalanced drilling services that was acquired by Weatherford in April 1999.