Enabling ultra-deepwater success when the economics are tight

The Stones development in the deepwater Gulf of Mexico poses numerous technical and economic challenges, but Schlumberger technologies combined with an unwavering commitment to safety and protection of the environment are helping to make it work. The wells constructed for Stones are some of the deepest and longest ever attempted. Perhaps the greatest challenge in the Lower Tertiary geologic frontier and other complex plays around the world is to get the job done safely and efficiently to achieve a competitive return on investment, even at low commodity prices. Here's how.

Drill faster, more reliably, with minimal trips

The Schlumberger engineered approach to drill Stones #9 was based on learnings from Stones #5R. Upon analysis of the drilling data, the engineering team was able to implement changes to the bottomhole assemblies (BHAs), optimize bit/reamer cutting structure, and define optimal drilling parameters through extensive modeling and simulation.

Schlumberger proposed using the fully rotating PowerDrive Orbit* rotary steerable system (RSS), one of the newest members of the PowerDrive* RSS family. Since its introduction in 1998, the PowerDrive system remains the only fully rotating steerable drilling system on the market. Over the years, refinements have continued to enhance tool reliability to increase system life and improve efficiency through precise directional control guided by real-time near-bit measurements.

Capable of operating at speeds up to 350 rpm, the PowerDrive Orbit RSS is faster, safer and more reliable than conventional systems. The high rpm limit improves steering control in the extensive stick/slip conditions endemic to these challenging wells. The system's six-axis continuous inclination and azimuthal gamma ray inform its unique inclination-hold feature to enable drilling the well's tangent and vertical sections with only minimal input from the directional driller. Drilling proceeds efficiently, with less interruption and more accurate well placement, while self-steering also delivers a smoother bore. Near-bit extended-range gamma ray measurements provide further well positioning data for improved real-time decisions.

The new pad actuation system of the PowerDrive Orbit RSS features metal-to-metal seals that can handle corrosive drilling fluids and demanding hydraulics.

The PowerDrive Orbit RSS expands the operating envelope of rotary steerable technology by extending system life, delivering precise directional control, and increasing drilling efficiency. (Courtesy of Schlumberger)

The PowerDrive Orbit RSS readily met the challenges of the Stones #9 production well, drilling shoe to total depth in a single efficient trip. Its high rpm capability powered a fast ROP to shave days from the rig schedule.

Optimize the well connection to the reservoir while perforating

Perforating all zones simultaneously saves valuable rig time compared with stacked completions that require separate trips to perforate each zone. Conducting the entire perforating job at once is also safer for the rig and gun crews, as they spend less time running pipe.

To address these challenges, Schlumberger engineers worked with their counterparts at Shell for more than a year to formulate completion plans for the Stones wells. In each case, Shell elected to use the 30,000-psi-rated Schlumberger IRDV* intelligent remote dual valve, INsidr* perforating shock and debris reduction technology and 30,000-psi Signature* quartz gauges.

In both Stones #9 and #5R, all zones were perforated simultaneously resulting in reduced rig time.

Increase productivity and recovery with subsea boosting

After perforating and installation of the completion hardware, the remaining connection for fluid flow—between the wellhead and the host production facility—is established with subsea equipment. The placement of modern subsea developments in ever deeper water depths and at increased distances

Examination of the spent 6 5/8-in. perforating gun incorporating INsidr perforating shock and debris reduction technology shows that the shaped charge cases do not break but remain in one piece, resulting in only negligible debris out of the gun. (Courtesy of Schlumberger)

INsidr technology was specified because it both manages perforating gun shock and minimizes the amount of debris left behind compared with conventional gun systems. Excessive perforating gun shock can cause significant damage to the lower assembly or completion tools. The proven PURE Planner* perforation job planning application is used to predict the peak incremental dynamic loads that can produce mechanical damage. Once the peak loads are identified, the software is used to modify the design of both the gun string and BHA to lower the peak loads to force values that are manageable.

Debris from perforating can pose problems during tubing-conveyed perforating and well cleanup operations. Using INsidr technology significantly reduces debris volume, as confirmed with official API 19B Section 5 debris tests. PowerFlow Max* 6618 slug-free big hole shaped charges were specified for deployment with INsidr perforating technology in the Stones wells to lessen the amount of debris created in the first place because their steel cases remain practically intact after the gun fires. Minimizing debris maximizes the area open to flow after perforating for the best possible production.

between the well locations and the host facility introduces pressure losses and temperature changes that can lead to flow assurance problems. Adding energy to the flow with subsea booster pumps overcomes the pressure losses and reduces the temperature losses by speeding up the flow. Although there are many examples of successful subsea boosting in fields around the world, none is in waters as deep or pressures as high as those of the Stones project.

The high shut-in pressure associated with Lower Tertiary reservoirs was one of the key issues for consideration in designing the boosting system for Stones. In addition, high differential pressure is required to increase both the production rates and the overall recovery factor, which would enhance project economics. Due to the potential for high cost and lost revenue if there is downtime, Shell required equipment with a proven track record and the highest reliability and performance. To meet these specifications, the final selection landed on using seabed pumps.

Shell is collaborating with OneSubsea, a Schlumberger company, to incorporate the company's requirements and specifications in the pump design. The project is being executed at OneSubsea's facilities for engineering, manufacturing and testing in Bergen, Norway.

To build the pumps, OneSubsea engineers are working with suppliers on every detail. A significant portion of this effort focuses on metallurgy, welding and manufacturing. To deliver the highest-reliability system, every component must be of the highest quality and rigorously evaluated before incorporation into the final assembly.

The OneSubsea single-phase pump systems for the Stones wells consist of a fully encapsulated pump and motor, designed for 10,000-ft (3,000-m) water depth and internal pressure up to 15,000 psi. (Courtesy of Schlumberger)

A critical step in the initial technology qualification program (TQP) involved the project teams going to individual suppliers to qualify the many elements of the pump system. As part of the final phase of the TQP, prototypes and first-article testing were successfully completed. The TQP was concluded with building, testing and qualifying a full-size pump prior to initiating manufacturing of the commercial pumps.

In the long term, seabed boosting allows producing the reservoir to a lower abandonment pressure, which increases the recovery factor and could extend the life of the Stones field considerably.

**Mark of Schlumberger*