

Experience, expertise and advanced technologies bring ambitious GOM project online

LLOG Exploration Company's ambitious deepwater Buckskin project in the Gulf of Mexico (GOM) illustrates the importance of collaborating with a service provider that has a track record for expert multi-disciplinary planning and integrating advanced technical solutions with flawless implementation to address formation challenges and minimize risk.

The project launched in January 2018 with two multizone development wells to 29,000-ft total depth (TD) in 6,800 ft of water. Key challenges included the lower completion frac job and a highly deviated hole with a sidetrack.

Schlumberger, a long-time service provider of LLOG, brought together expertise and technologies from drilling fluids, wireline, testing services, and completions to help meet the operator's objective to begin first production in mid-2019.

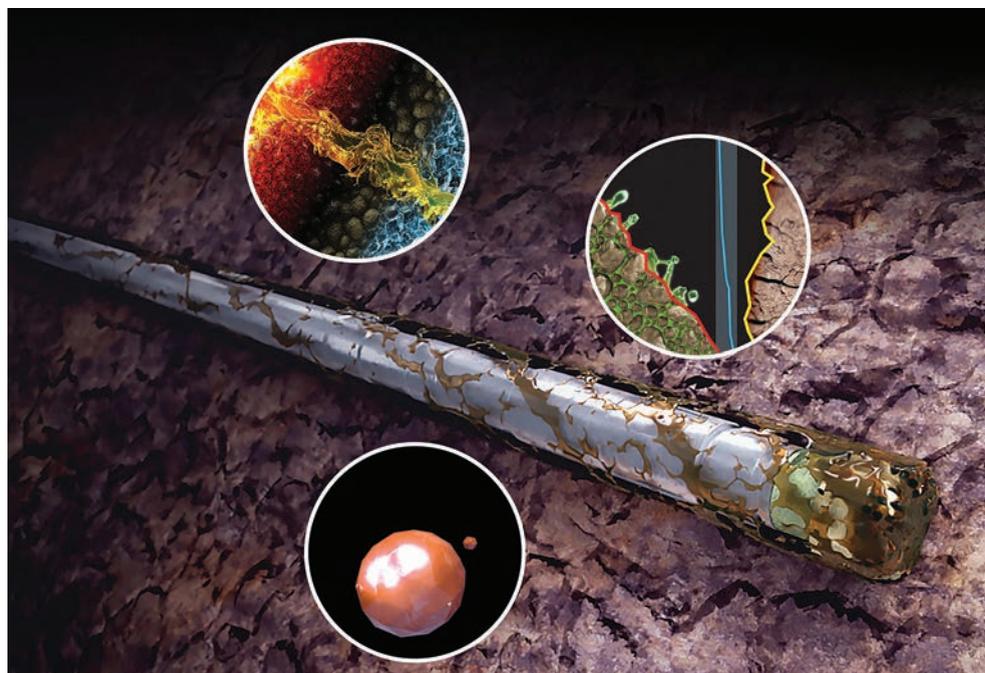
Optimized operations with flat rheology fluid

The narrow hydraulic window between pore and fracture pressure required a synthetic-based mud (SBM) system to optimize high-angle (60° maximum) drilling efficiency. Excellent sag prevention would be essential to avoid time-consuming conditioning trips during the subsequent extensive logging program.

M-I SWACO, a Schlumberger company, selected the new RheGuard* flat rheology drilling fluid system that delivers the low rheological profile and reduces sag potential as required for intricate intervals drilled in deepwater and other complex wells. This innovative single-fluid solution ensures enhanced ROP, trouble-free pipe running, and high-integrity casing and liner cementing while minimizing losses.

Flat rheology is a concept defined by the uniformity of rheological properties and gel structure over a range of temperatures, pressures or shear rates. The goal from the drilling perspective is to minimize the contribution of the drilling fluid on (annular) frictional pressure losses and help mitigate loss circulation events while

conditioning before running casing or liner or they compromised drilling rates in order to isolate the overburden formations and provide a strong shoe for the sections to be drilled ahead. The RheGuard fluid system was engineered to be independent of the conditions prevalent in most deepwater drilling scenarios.



The RheGuard flat rheology drilling fluid system delivers the consistently lower ECD and sag potential required for intricate intervals drilled in deepwater and other complex wells offshore.

drilling large hole sections. The RheGuard system advances flat rheology with the capability to run a thinner cold-temperature rheological profile and gel structure than the high-temperature profile, providing a reversed rheology effect and significantly reducing riser pressures.

Some first-generation flat rheology systems could deliver clean wellbores, but they required excessive rig time for con-

Field-trialed in LLOG wells before deployment at Buckskin, the RheGuard system's engineered combination of components provided the necessary properties for considerably improving drilling rates and raising the zonal isolation success rate during casing cementing. The unique RheMul* flat rheology system emulsifier was used to ensure excellent emulsion stability for consistently lower equivalent circu-



ance system integrating tool taxis, angled hole finders and cable standoffs.

XL-Rock* large-volume sidewall coring service was deployed to obtain critical formation samples with 100% core recovery. Average drilling time was less than 9 minutes per core, achieving at least an 80% reduction from typical drill times exceeding 45 minutes in the formation.

Seven open-hole and two cased-hole descents were conveyed on 30,000-lb torque-balanced composite wireline cable to complete logging in 190.5 hours with zero non-productive time (NPT). A cast iron bridge

Quanta Geo service achieves high-definition imaging by applying 192 microelectrodes at high vertical and horizontal resolution.

lating density (ECD). RheCon* flat rheology system conditioner quickly prepared the RheGuard system for running and cementing casing when logging was completed.

The fluid system optimized ECD management, decreased mud losses, enhanced penetration rates and improved well-bore stability. Outstanding fluid stability enabled effective logging over eight days at static well conditions with maximum temperature to 236°F and no barite sag incidents. Drilling fluid cost per foot in SBM intervals was reduced by 40% compared with offset wells.

Mapping the ideal trajectory to unlock the reservoir

Schlumberger Wireline deployed state-of-the-art technologies to identify the ideal trajectory for accessing the massive pay in the second sidetrack. The Quanta Geo* photorealistic reservoir geology service redefines high-definition imaging in nonaqueous-based mud to accurately represent formation geology. The Rt Scanner* triaxial induction service is ideal for wells at any deviation because it determines vertical and horizontal resistivity while simultaneously solving for formation dip.

The Wireline team successfully logged the 60° deviated hole through a milled window and aggressive 4°/100-ft dogleg severity to reach 29,300-ft TD at 22,000-psi borehole pressure. The high deviation was easily managed by a wireline convey-

plug for the whipstock was set with the ReSOLVE* instrumented wireline intervention service, saving valuable rig time. The ultrahigh-strength cable also prevented a stuck tool fishing job, giving LLOG confidence to proceed with logging.



The IRDV dual valve improves operational speed and efficiency by using direct or sequential commands to eliminate the need for complex indexing systems.

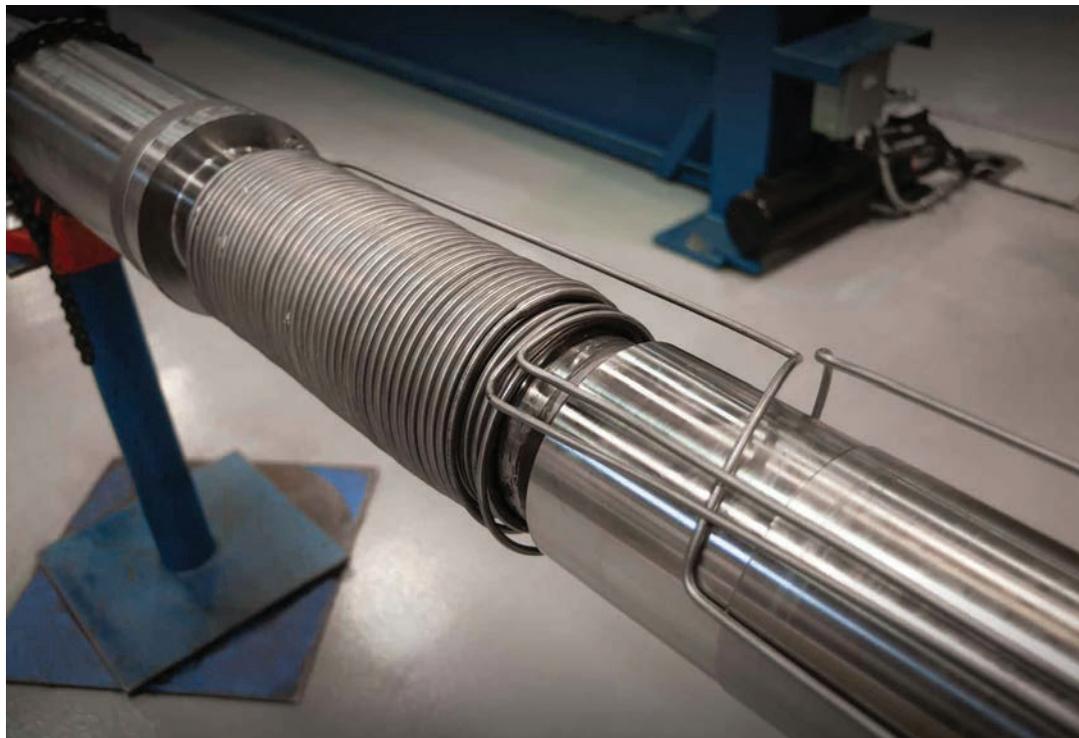
Intelligent TCP services

The deepwater experience of Schlumberger Testing Services was instrumental in delivering eight successful tubing-conveyed perforating (TCP) runs with more than 29,000 charges and no misfires. Services included the IRDV* intelligent remote dual valve and eFire-TCP* TCP electronic firing head controlled with low-intensity annular pulses from the IRIS* intelligent remote implementation system.

The IRDV dual valve system pairs tester and circulating valves cycled independently or sequentially for greater flexibility. The dual valve enhances safety with lower-pressure operation and no need for the nitrogen pre-charges typical with mechanical downhole test valves. Automatic sequencing and multiple movements from a single command accelerate valve cycling to save three to four hours per average run over mechanical valves.

The electronic firing head avoids the rigid conditions necessary with conventional methods and allows the operator to abort firing at any time. Precise delay times, low-pressure initiation and insensitivity to well conditions expand the safety margin. The electronic firing head also provides fast gauge data to verify dynamic underbalance.

INSidr* perforating shock and debris reduction technology minimized the potential for excessive gun shock, which can cause major damage to the lower assembly or completion. INsidr technology significantly reduces debris volumes, as confirmed with official API 19B Section 5 debris tests.



The TRC-II tubing-retrievable charged safety valve is a surface-controlled subsurface valve that uses a gas-spring design with gas-powered actuators to enable installation at depths significantly deeper than possible with conventional spring-type designs.

Flawless safety valve deployment

As LLOG's longtime supplier of the field-proven 15,000-psi-rated TRC-II* tubing-retrievable charged safety valve, the Schlumberger Completions team effectively met the challenges of the Buckskin wells. Operated with low pressure and deployable at depths greater than 12,000 ft, below where hydrate and paraffin deposits form, these valves improve the effective life and reliability of the completion.

Tubing size requirements resulted in changing the upper and lower subs at the last minute from the 4½-in TRC-II valve to a 5½-by-4½-in size. Proprietary software used to predict valve operating pressure for a specific application precisely matched valve parameters to well conditions before installation. The customized adjustment was expedited through the Schlumberger Houston Product Center to make an on-time delivery, and the valves were deployed flawlessly in both wells.

Experience, expertise and integration of multiple advanced technologies were pivotal in bringing the first phase of the Buckskin project to fruition. The collaborative, multidisciplinary process helped LLOG overcome the challenges and risks presented by the complex wells and formation to initiate production and move to the next phase.

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