

ALWD system maintained well control during perforation, avoided killing well

A customer in Azerbaijan drilled a complex high-pressure extended reach gas well to 22,343 ft (6810 m) to increase gas production to over 9 billion cubic meters annually. The greatest challenge was how to perforate the well without leaving perforating guns in the well, across the perforating zone, or without killing the well to recover the spent guns. The conventional solution of drilling a rat hole to allow the guns to drop after detonation was ruled out as was the use of a lubricator valve. Moreover, the inclusion of a high end kill weight fluid and operation which would be designed to minimize the formation damage so that the guns were recovered from a dead well could cost the customer upwards of \$2 million in addition to the potential risk of taking on such an operation.

Even though this was a newly drilled well, Baker Hughes used an intervention philosophy to support this complex project, as several of the key solutions are critical in through tubing intervention operations. Drawing on expertise from multiple disciplines, the Baker Hughes team in Azerbaijan worked with the product lines and the Remedial Completions team in Houston to plan a fully integrated approach to overcome all the customer's challenges. Baker Hughes proposed the TeleCoil[™] intelligent coiled tubing service to deploy and recover around 500 ft (152 m) of 2 7/8 in. Predator ZX[™] super deep-penetrating perforating charges which were deployed and recovered from the live well in conjunction with the Snapshot[™] advanced live well deployment (ALWD) system.

The reasoning behind combining these industry leading technologies was to deliver a robust solution which enabled the complete perforating assembly to be deployed into a live well environment safely and in one run, maximizing the static and dynamic underbalance. Furthermore, by utilizing HP/HT TeleCoil, Baker Hughes was uniquely qualified to carry out real-time correlations prior to firing with a surface-activated guardian firing head.

A program of this magnitude carried substantial, inherent risk. To streamline the overall project and assist in reducing the operational risk, the Remedial Completions team assigned a project manager on location during the operation as well as during the planning phase. During the planning phase, the project manager coordinated several product lines, worked

Challenges

- Perforate extended reach gas well
- Avoid killing the well to recover perforating guns
- Prepare for all contingencies
 associated with high
 surface pressure

Results

- Perforated and recovered in one run
- Maintained full well control during the operation through the coiled tubing surface stack with the inclusion of surface gate valves
- Experienced zero HSE issues and minimal NPT

with them directly, and delivered a unified plan to finalize the complicated project. His industry knowledge, and that of all the Baker Hughes personnel, directly contributed to the success of the project. During the planning phase of the operation, several detailed simulations using various proprietary modeling programs. The coiled tubing modelling was completed with the CIRCA™ coiled-tubing simulation and analysis software which enabled pre-operation modeling of the string with sufficient safety margins for this high-pressure operation. The most recent addition to the software, CIRCA RT Real-time CT simulation and analysis software, was used on location to assist the field specialists by providing transient updates of the forces and operational limits, changes to string fatigue and constant monitoring and warnings of time-based changes to the operation.

Advanced job planning and modeling analysis was conducted following Baker Hughes TerraCONNECT™ perforating solutions methodology featuring the PulsFrac™ dynamic-event modeling software. Built on advanced analysis and job planning data in the TerraFORM™ flow-optimization reservoir modeling service, Baker Hughes evaluated and optimized the total underbalance event (static and dynamic) to deliver an optimized perforating solution for maximum productivity. The high pressure on the wellbore expected after the perforating

event was an obvious concern in terms of the overall effect on coiled tubing.

The TerraGARD™ gun-shock wave predictor and risk detection evaluation was subsequently run to estimate total loads on the coiled tubing at the moment of detonation, and supplied engineering confidence in the job execution. After extensive testing and planning, including a dummy/drift run, the perforating guns were deployed into the hole via TeleCoil under live well conditions. At total depth, the crew carried out a real-time correlating pass to ensure the guns were fired at the precise position. In addition to realtime correlating the perforating guns were fired by way of surface activated Guardian firing system therefore removing the need to pump a ball and pressure up.

The perforating BHA was then recovered to surface where BHA was reconfigured to commence the live well recovery of the 500-ft (152-m) perforating string. During this phase of the operation the use of a real-time compression/tension sub and TeleCoil assisted in streamlining the whole recovery operation under pressure as the engineers are able to see the exact weight being applied to Snapshot connectors as they connect the running tools to the assembly hanging in the deployment BOP and disconnecting the modular gun assemblies.

All the perforating guns were recovered in less than 24 hours. After the crew confirmed all guns had detonated as expected, the well was then opened up and the production figure exceed expectations.

The production figures from the reservoir are testament to the overall integrated solution and the upfront analysis carried out to maximize the perforating clean up through dynamic and static underbalance. In addition to the production figures, the overall project was delivered without any health, safety and environmental (HSE) incidents, in an efficient manner and with minimal nonproductive time (NPT).



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