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Dynamic Underbalance Perforating System Helps Exceed Injectivity Estimate by 6,000 bbl/d

Running PowerJet Nova charges and the PURE* clean perforations system enhances operations in deepwater reservoir, Southeast Asia

CHALLENGE

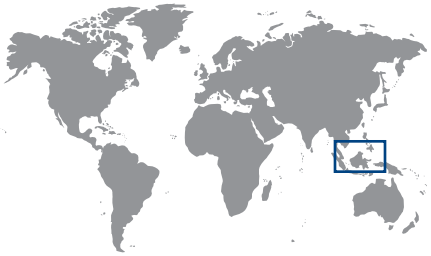
Effectively perforate a deepwater reservoir to increase production while minimizing perforation damage and skin.

SOLUTION

Build and deploy a customized horizontal perforating gun string that includes PowerJet Nova* extradeep-penetrating shaped charges to provide the deepest-possible penetration; the PURE system for clean perforations and more-efficient tunnel cleanup; and the flexible eFire* electronic firing head delete for safer, more economical operations.

RESULTS

Attained 2,500-psi [17.2-MPa] dynamic underbalance that helped achieve 18,000 bbl/d postwell injectivity, exceeding customer expectations by 6,000 bbl/d.



Perforate long horizontal interval of deepwater reservoir

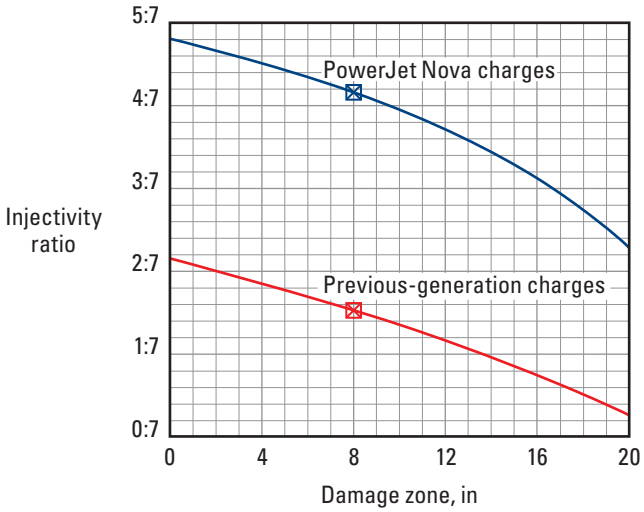
Injector wells in a deepwater reservoir in Southeast Asia provide integrated pressure support for production. One injector well, drilled in water depth of more than 4,000 ft [1,219 m], has a nearly horizontal section that was to be perforated over many separate intervals. Upon successful perforation, the intervals would be hydraulically fractured to increase flow efficiency; injectivity performance thereafter was expected to be 12,000 bbl/d.

Achieve extradeep, clean penetration with flexible control

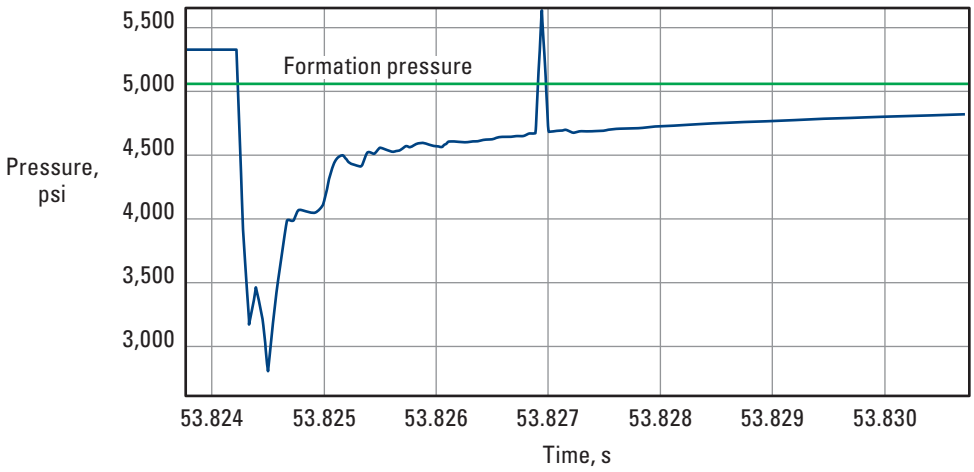
The operator collaborated with Schlumberger to determine the best-possible perforation methodology to meet test objectives. Realistic rock properties were fed into SPAN Rock* stressed-rock perforating analysis software. Additionally, PURE system software was run to determine the optimal dynamic underbalance pressure level that would ensure effective cleanup of the perforation tunnels for better injectivity.

The results of the two studies were evaluated, and Schlumberger recommended using PowerJet Nova extradeep-penetrating charges coupled with the PURE system for optimal perforating operations. PowerJet Nova charges improve efficiency by transferring explosive energy into the perforating jet, dramatically increasing penetration. Whereas conventional perforating relies on a large, static, initial underbalance that is established before guns fire, the PURE perforating system enhances the dynamic underbalance immediately after the perforation cavity is created, removing perforation debris and crushed-zone damage and creating more-productive perforation tunnels.

These two technologies were used along with an eFire electronic firing head to provide safer, more-efficient, and cost-effective perforating. This unique system creates pressure pulses that are converted into a special signature to communicate with the firing head. The system head does not require prerecorded downhole parameters, providing total control over the perforating operation.



A plot derived from SPAN Rock software shows that using PowerJet Nova charges would provide the best injectivity performance for the job.



A downhole gauge captured the 2,500-psi [17.2-MPa] underbalance created by the PURE system. This dynamic underbalance removed perforation debris from tunnels immediately after guns fired.

Exceed injectivity expectations with optimal perforating configuration

The well section was perforated using the proposed charges, technique, and firing mechanism. The perforation length totaled approximately 1,880 ft [573 m] with an additional 1,110 ft [338 m] of spacer sections. During perforation, downhole gauges measured a 2,500-psi [17.2-MPa] dynamic underbalance, which facilitated effective cleanup of the perforation channels.

Further, postperforation injection performance was measured at 18,000 bbl/d at the same injection pressure, a significant increase from the expected injection rate of 12,000 bbl/d. Every stage of the operation was successfully executed and completed, allowing fracture operations to begin.

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