Case Study

Perforating System Improves Efficiency and Reduces Risk in Ultradeep, Ultrahigh-Pressure Deepwater Well

INsidr technology helps save USD 3.6 million in 20,000-psi Gulf of Mexico well completion

**Challenge**

Perforate nearly 1,300 ft over four zones in large-diameter, heavy wall casing at a measured depth of more than 28,000 ft and pressure greater than 20,000 psi with a system capable of producing sufficient area open to flow (AOF) for a frac-pack completion, all in a single run.

**Solution**

Run a 30,000-psi-rated, tubing-conveyed perforating (TCP) string consisting of the IRDV* intelligent remote dual valve, PosiTest* retrievable compression packer, and high shot density guns with INsidr* perforating shock and debris reduction technology; use dual eFire* electronic firing head systems for initiation of the ballistic train and SXVA explosively initiated vertical shock absorbers to provide additional protection for the upper string and packer.

**Results**

Completed entire operation as planned with no NPT or HSE incidents, and perforated four zones in a single trip, saving USD 3.6 million. All guns fired normally, all tools operated flawlessly, and the entire BHA was retrieved with no delays and no damage; high-speed pressure data recorded at the firing heads matched prejob simulation results, verifying the accuracy of the shock model.

**Ultradeep, ultrahigh-pressure well required high-performance perforation technique**

Chevron’s Well PS003 in the St. Malo field is the first development well drilled in the Jack/St. Malo lower-tertiary project. The lower-tertiary trend targets low-permeability, deep Wilcox sands. As with the heavily developed Miocene plays in the Gulf of Mexico, sand production is a risk, so the completion design called for frac-pack stimulation.

With a total depth greater than 28,000 ft (MD) and reservoir pressure greater than 19,000 psi, 9¾-in, 65.1-lbm/ft, Q125 SLSF-grade production casing was used over the producing intervals. To successfully perforate this wide casing, a large-diameter gun system was needed. Standard-service 7-in guns are not applicable for these extreme pressures, but the 7-in HP HSD* high shot density guns with INsidr technology, loaded at 18 shots per foot with PowerFlow* slug-free big hole shaped charges, would meet these requirements.

**INsidr technology chosen as shock- and debris-reduction solution**

Well evaluation identified four separate zones for perforation, stimulation, and completion. At just less than 200 ft each, these zones spanned a total length of nearly 1,300 ft. At such extreme depths, very large pressure transients are produced in the wellbore at the time of gun detonation. Extensive laboratory tests and high-speed pressure data from thousands of actual perforating jobs have enabled Schlumberger to develop an accurate perforation modeling program to simulate and analyze the dynamic wellbore response when guns are fired. Prejob modeling results indicated that the maximum dynamic underbalance at the top of the gun string would be 35% less with INsidr technology. This reduction in peak dynamic underbalance corresponded to a 230,000-lbf reduction in the maximum tensile load on the TCP packer.
CASE STUDY: INsidr technology proves value in ultrahigh-pressure well, Gulf of Mexico

Four zones completed in 1 day saved USD 3.6 million
The design of the INsidr loading tube prevents fragmentation of the shaped charge cases, eliminating the main cause of perforating debris. Witnessed API RP19B Section 5 testing resulted in only 91 g/ft of total debris. Of this amount, only 65 g fell out of the 5-ft gun during the postshot gun-rotation phase. On the St. Malo well, more than 14,000 big hole shaped charges were detonated simultaneously to prepare the well for a multistage frac-pack completion. Postperforating cleanup runs recovered zero perforating debris, and there have been no operational complications associated with perforating debris.

In this instance, the ability to safely and efficiently run such a long gun string and perforate all four zones in a single trip saved Chevron USD 3.6 million. Less quantitative but equally important was the benefit of reducing the risks associated with deploying and retrieving long, heavy gun strings in a well of this depth and reducing the possibility of a well integrity incident due to equipment failure or damage.

Cutaway of gun with INsidr technology after firing. The INsidr technology prevents fragmentation of the shaped charge cases, eliminating the main component of perforating debris.