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Maximizing Injection Performance Through Fit-for-Purpose Dynamic Underbalance Perforation Using Unconventional Gun System in Offshore Well, Sarawak, Malaysia

Abstract

The perforation strategy of Dynamic Underbalance (DUB) created the surging effect to remove debris from the perforation tunnels, thus reducing skin for optimal injectivity in this offshore development water injector well in Malay Basin, Offshore Sarawak. The objective was to inject up to 18,000 bwpd for pressure maintenance purposes.

In the design phase, perforation software was used to perform the simulation iterations by sensitizing on the number of empty tubing conveyed perforation (TCP) gun chambers added at the top and bottom of perforation intervals. However, due to small gun size (4-½ in.), limited rat hole length and high static underbalance (1,000 psig), the desired amount of DUB using conventional empty gun volume only was not possible to be achieved. As a result, an innovative approach using two Pressure Operated Tester Valves (POTV's) was proposed, to create additional empty space inside the tubular between the POTVs above the packer. However, this created additional challenges which had to be overcome.

Presence of empty tubulars in between the POTVs prevented the required hydraulic pressure transmission through the tubulars to activate the perforation guns via normal hydraulic TCP firing head. Therefore, a specialized firing system was required, which consisted of an acoustic communication system triggering downhole electronics to actuate a standard TCP firing head (Top-Fire Dual) - a first for this type of firing head.

The POTV was activated by applying a pre-set annular pressure. Opening lower POTV, after the perforation fired, will create the required DUB surge, around 1,000 psi, which help cleaning up the perforation tunnels. Downhole fast gauges (recording in microseconds range) were run as part of the assembly to measure and to confirm the created DUB effect.

Both fast gauges as well as acoustic gauges confirmed that 300 psi DUB was created upon gun firing and around 1,000 psi surging was achieved after the two POTVs were opened. Maximum losses recorded at 525 gallons per minute were observed following perforation. The well's injectivity performance was evaluated by performing step rate test and the result confirmed the well was able to meet higher injection rate than the plan.