For successful deepwater completions—select, displace, filter

Innovative engineering design maximizes reservoir productivity

DENISE ALLEN ZWICKER, *SPECIAL CORRESPONDENT*

TODAY'S CHALLENGING Gulf of Mexico deepwater completions require new technologies to protect reservoirs and maximize their productivity. Key considerations include:

- Precise selection of the appropriate completion fluid: compatible with associated fluids, sufficiently dense at the seafloor—and fully capable of inhibiting gas hydrates, which form readily at the high pressures and low temperatures at the BOP/wellhead of deep subsea wells. Gas hydrates plug choke and kill lines, BOPs, risers and flowlines in a kick. They also interfere with drillstring movement and BOP operation—and can liberate large quantities of gas near the surface as they decompose or melt.
- Carefully engineered displacement before introducing completion fluid: mechanical and chemical cleaning, hydraulics modeling, and spacer-train design and testing. This level of displacement eliminates stuck packers, corroded tubulars, damaged formations, problems with setting tools and placing cement, excessive filtration time and cost, increased disposal costs—not to mention reduced reservoir productivity.
- High-capacity filtration, which improves both operational and HSE performance. The most active deepwater operator in the Gulf of Mexico chose Newpark Fluids Systems for three important completions from an ultra-deepwater, dual-activity drillship. In each case, the operator benefitted logistically from the company's new facility in Port Fourchon, Louisiana.

Newpark's completion-fluids facility in Port Fourchon incorporates the latest automated workflows and HSE standards.
(Courtesy Newpark Fluids Systems)

A LOGISTICAL SUCCESS STORY

For a subsea decomplete in 4,500 ft (1,372 m) of water, the Newpark team engineered a sophisticated displacement, with chemical and mechanical wellbore cleanup, and three major steps: displacing to brine, recovering tubing, then displacing to synthetic-based drilling fluid.

The planned decomplete did not, initially, specify the circulation of brine below the mudline. When the operator's plans changed, the team built and delivered the additional volume in less than 12 hours. The working fluid was a 13.5 lb/gal. (density) calcium bromide/calcium chloride clear brine designed for a 30°F true crystallization temperature at 15,000 psi.

To prepare, team members cleaned the rig's surface fluid-handling system while the drillship moved to the new location. The new, more comprehensive plan managed multiple fluid interactions, including six fluid transitions. Berms controlled tubing debris during the washing and thread cleaning. Increasingly finer shaker-screen meshes minimized solids.

The team recovered the incumbent packer fluid with little to no density or volume loss, and logistics went smoothly, with no nonproductive time.

EXCEEDING OPERATOR OBJECTIVES

On another deepwater well, Newpark set out to directly displace a 14.0 lb./gal. low-equivalent-circulating-density (ECD), synthetic-based fluid to a 13.7 lb./gal. calcium bromide/calcium chloride completion fluid. Displacement volume was 3,482 bbl, and well depth was 27,000+ ft (8,200 m). The operator set cleanliness specifications at less than 30 nephelometric turbidity units (NTUs) from the well, with a solids content below 0.05%.

The results? Total displacement time was 17.75 hours—from filling service lines with brine to the fluid-clarity endpoint—and involved circulating 3.3 well volumes. Final fluid clarity was 17 NTUs and less than 0.01% solids, handily exceeding both operator targets. All spacers returned to the surface as expected, based on bbl/stroke calculations.

The successful displacement resulted from specific chemistries, reliable hydraulics modeling, robust wellbore cleanup tools and proper filtration.

Laboratory tests helped qualify the proposed chemistry, as well as the spacer-train formula. The hydraulics modeling of the displacement addressed contact, annular velocity, flow regime and annular volumes. Mechanical tools were placed, in sequence, to clean the wellbore and riser. High-flow filtration permitted pump rates of as high as 30 bpm, keeping pace while the riser was boosted.

The rig's surface fluid-handling system, removing all synthetic-based drilling fluid. The drilling fluid was circulated and conditioned, to specifications, before displacement. The transition and cleaning spacers used a blended solvent/surfactant, custom designed for the drilling mud it displaced.

Using base oil and cleaning spacers, team members first displaced the choke, kill and boost lines to completion fluid at 5-10 bpm, then pumped the spacers down the work string at 6-9 bpm. They followed with the completion fluid, pumping between 14 and 18 bpm until the tail end of the viscous spacer passed above the BOP, when the remaining displacement reached flow rates of 25 bpm.

During displacement, team members rotated the work string and wellbore cleanup assemblies between 30 and 60 rpm. Similarly, they reciprocated the work string between 60 and 120 ft (18 and 37 m)/min after displacement spacers exited the string. The clean tools, post-displacement, demonstrated the chemistry's excellent removal of fluid residue from the tubulars.

Plenty of pit space made it possible to filter all surface completion fluid before displacement, rather than during. After the fluid returned to the surface, a flocculant-treated brine was reverse-circulated before the riser was boosted. After a short trip, the BOPs were jetted, and the riser boosted a final circulation.

A THIRD DEEPWATER SUCCESS

The same operator—again in 4,500 ft of water, for a 29,000+-ft well—wished to directly displace a 14.1 lb/gal., low-ECD, synthetic-based fluid (3,183 bbl) to a 14.3 lb/gal. pure calcium-bromide completion fluid. The operator set the same cleanliness specifications as above: less than 30 NTUs and less than 0.05% solids.

Again, Newpark team members tested their plans in the lab, qualifying the proposed chemistry and spacer train, as well as modeling the hydraulics. They specified mechanical wellbore cleanup tools and high-flow filtration equipment. On the drillship, they cleaned the rig's surface fluid-handling system, circulated and conditioned the drilling mud, and applied a blended solvent/surfactant for spacer transition and cleaning.

They likewise first displaced the choke, kill and boost lines, then pumped the spacers down the work string at 9.5-10 bpm, and followed with the completion fluid at 10 bpm (above the BOP at 27 bpm). The same 30-60 rpm rotation of work string and wellbore cleanup assemblies, along with 60-120 ft/minute reciprocation after the spacers exited the work string, successfully removed fluid residue. The same pre-displacement filtration and reverse-circulated lead brine preceded a short-trip, BOP jetting and riser boosting.

Total displacement time was 22 hours, with 3.5 well volumes circulated. Clarity was 24 NTUs, with less than 0.01% solids, again exceeding operator targets.

In this case, the operator requested formulation of a calcium-carbonate fluid-loss pill—if needed after the frac-pack. Newpark considered reservoir properties, perforating information, fracture parameters, and screen and proppant data, developing and evaluating the pill at its Houston Technology Center.

When the fluid-loss-control device failed to close properly, and losses exceeded the operator's threshold, team members quickly mixed and spotted the pill, monitoring the steadily declining losses for 1.5 hours. The pill was 100% effective at preventing fluid losses for the next 48 hours, permitting removal of the service tool and continued completion.

LESSONS LEARNED

All three case histories demonstrate three major lessons:

1. Well-engineered displacements reduce operating costs and risks. Displacement software models placement, pump rates, flow profiles, riser boost, annular coverage and contact times for each element of the spacer train. The software can model as many as nine flow paths and 12 fluids used in a deepwater displacement. It also enables the user to run animated, 2D simulations of the displacement scenario, calculating and presenting circulating temperatures, pressures, ECD, volumes, horsepower and fluid compressibility. This makes for reduced operational costs and improved project economics.
2. High-capacity filtration units improve both operational and HSE performance. Designed to operate at flow rates as high as 35 bpm, they include HSE features such as hands-free electrical pumps with pressure-relief valves and a central control panel for remote operation.
3. Best-in-class facilities improve logistics and, therefore, response time. These strategically situated offshore supply bases offer operational efficiencies, such as large capacity, the ability to mix specialized fluids, to transfer fluids at high pump rates, and to simultaneously mix, load and transfer fluids. Designed with great attention to HSE goals, these highly automated facilities offer consistent, repeatable processes.