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The objective was to effectively displace the drilling fluid and ensure the cleanliness of well-bore tubulars thus optimizing the conditions for running the upper completion. As such it was essential to efficiently remove all mud and pipe dope residues, whilst minimizing the rig time involved. StatoilHydro required returning seawater, behind the final surfactant pill, to show three consecutive NTU readings below 100 as the criteria for a clean well. This well was particularly challenging due to the high angle of the 7” liner and reduced annular velocities achievable in the 13-3/8” casing and marine riser. Due to environmental regulations all returning fluids had to be contained on surface before transferring to an injector well. Therefore due to the limited surface capacity and injection time, it was essential to minimize the waste volume generated. All products proposed for use in the pill train had to comply with strict Norwegian environmental legislation.

Halliburton’s Solution – Baroid designed a customized pill train sequence using displacement software to ensure optimal contact time of surfactant pills whilst maximizing pump rates and subsequent annular velocities.

A base oil spacer was placed at the front of the pill train to initiate cleaning and thin the tail end of the drilling fluid to aid an effective displacement. It was decided to include BARAKLEAN® DUAL casing wash at a concentration of 13% v/v in a weighted, viscosified push pill directly behind the base oil. This would be the first time that this product would be used in Norway although the product had previously exhibited high cleaning performance in other geographic locations, and in lab testing, due to the dual functionality solvent / surfactant content.

Operator’s Challenge – StatoilHydro asked Baroid to design and execute a direct displacement from the 1.55sg XP-07 oil based drilling fluid to seawater for a well in the Visund oil and gas field of the Norwegian North Sea. Heavily faulted, with several different fluid contacts, the Visund reservoir generally is contained within three main tilted fault blocks sealed by shales and claystones. The two principal reservoir units are the Brent Group and the Amundsen and Statfjord Formations.

Drilled and completed as a gas injector to support production from the depleted Etive and Tarbert formations within the Brent reservoir unit, the subject well was planned for a smart completion with installation of a DIACS (downhole instrumentation and control system) which allows reservoir flow management in both producers and injectors. Because these sophisticated completion types require clean wellbore conditions prior to installation and operation, oil based mud displacement and wellbore clean up is of paramount importance.

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The combination of solvent and non-ionic surfactant in BARAKLEAN DUAL casing wash reduces the risk of oil and water sludges forming when trying to displace oil based fluid with an aqueous based spacer train. The surfactant portion also aids the water wetting of wellbore tubulars. Additionally this product is classified for use under Norwegian environmental legislation. A viscosified BARAKLEAN GOLD surfactant pill was included after the BARAKLEAN DUAL pill to assist the cleaning process.

To increase the annular velocity in the 13-3/8” casing, a circulation sub was placed in the clean up string above the liner top. Once the initial set of pills was circulated around the high angle liner section, the circulation sub was opened to allow a higher flow rate through the 13-3/8” annulus and riser. A further BARAKLEAN DUAL pill, followed by a secondary BARAKLEAN GOLD pill, was pumped through the circulation sub to enhance cleaning in this section. The final surfactant pill was followed by seawater.

Three consecutive NTU readings below 100 (81, 69 & 53) were achieved after only 70 m³ returning seawater behind the final surfactant pill. Having met the criteria for a clean well, the seawater was displaced to packer fluid before pulling the clean up string to surface. The string was described as “very clean” on inspection at surface.

**Economic Value Created** – Due to the efficiency of the clean up pill train, the well met cleanliness criteria much earlier than expected. The clean up operation was completed in 11 hours, compared with the estimated operational timing of 30 hours. This saved 19 hours of rig time, estimated to be worth in excess of $500,000. Consequentially, as pumping time was reduced, the volume of waste fluid requiring injection was reduced. The clean wellbore allowed the upper completion to be run and set without issue. StatoilHydro was pleased with the timeliness of the operation and high quality job design.