

First Use of Novel High-Density Monovalent Brine Enables Safe Displacement Operation

EXTENSIVE TECHNICAL TESTING, COLLABORATIVE ENGINEERING, AND LOGISTICS PLANNING FACILITATED WELL COMPLETION AT THE NECESSARY OVERBALANCE

NORTH SEA

CHALLENGE

- » Keep well in overbalance during clean-out operation
- » Ensure high-density brine is compatible with formation mineralogy
- » Have sufficiently high density with a TCT < 2°C

SOLUTION

- » Use TETRACS Neptune® HDM brine technology to achieve density requirement
- » Test TETRA CS Neptune HDM brine for compatibility with the reservoir rock
- » Engineer a displacement plan involving multiple pills for an effective clean-out, while also providing overbalance in case pump stops

RESULTS

- » Obtained clean well within planned volumes
- » Maintained well integrity
- » Completed well successfully without any issues

OVERVIEW

A major operator drilling offshore in the North Sea was planning to re-complete and convert their well to a dual gas injector. There were several risks associated with the clean-up operation when displacing the wellbore from 1.55 sg (12.9 lb/gal) INNOVERT® NS to 1.51 sg (12.6 lb/gal) sodium bromide (NaBr) brine prior to running the upper completion. The main measure of success was to stay overbalanced within the expected formation pressure (1.474 sg / 426 bar) when displacing 1.51 sg (12.6 lb/gal) NaBr brine into the wellbore and tripping out of hole.

CHALLENGE

When drilling an adjacent well in the same formation, pore pressure turned out to be higher than initially anticipated in the Planning phase. Originally, the pore pressure was to be mitigated by using 1.48 sg (12.35 lb/gal) brine; however, it soon became clear this would not provide the necessary overbalance required to complete the well with the desired level of safety. Halliburton Baroid managed to mobilize 1.52 sg (12.7 lb/gal) TETRA CS Neptune® HDM brine in a very short time to relieve the higher pore pressure.

Some of the major risks and challenges identified for the wellbore clean-out were:

- » Stay in overbalance above the expected 1.48 sg formation pressure
- » No swabbing when pulling out of hole (POOH) after clean-out
- » No fracturing of the formation when pumping a heavy push pill, and still be in overbalance should the pump fail
- » Use a brine at the required density and true crystallization temperature (TCT) compatible with formation mineralogy and fluids

The primary objective was to complete the operation safely, both with respect to personnel and the environment. Other objectives included minimizing time spent on pit cleaning and completion fluid mixing, while also avoiding fluid contaminations and minimizing slop production. The maximum re-use of the brine would be financially beneficial to the client.

SOLUTION

Several compatibility tests were performed using different brines for other projects in similar formations, assessing formation mineralogy and formation water. In these tests, both the potassium formate and calcium bromide brines were excluded due to incompatibility with shale mineralogy. Cesium formate brine was found to be compatible but would add more cost to the project. Monovalent brine was demonstrated to be the optimum solution, with respect to both reservoir rock and formation water compatibility.

Standard NaBr brine will, at a stock density of 1.50 sg (12.5 lb/gal), have a TCT of +7°C. Adding more salt to increase density would give higher TCT values, leading to a risk of salt crystallization during operations. To ensure a sufficient pressure safety margin in this well, a brine density of 1.51 sg (12.7 lb/gal) was required, which could not be achieved with standard monovalent brine. The solution was to utilize Halliburton Baroid's partnership with TETRA Technologies and apply their TETRA CS Neptune® HDM brine technology for the very first time in this well.

A blend of 1.558 sg (13.0 lb/gal) TETRA CS Neptune HDM brine with 1.50 sg (12.5 lb/gal) NaBr brine to achieve a final density of 1.52 sg (12.7 lb/gal) was formulated in the liquid mud plant at the onshore base. A sample of this brine was measured in the Halliburton lab to have a TCT of < -4°C.

PROJECT DETAILS

A detailed execution program was prepared to outline all steps of the operation, including a full risk assessment, detailed pit plan, and completion fluid graphics (CFG) hydraulic simulations. The CFG simulations showed that the well would be in underbalance by pumping a conventional clean-up pill train. An optimized pill train was designed; with modeling showing that a high-density push pill would remain below the fracture pressure of the formation and a reduction in wash pill volume would still provide an efficient clean-out.

The clean-out bottomhole assembly (BHA), supplied by the Halliburton Completion Tools team, included magnets, scrapers, brushes, and a circulation sub-assembly. Additionally, the Turbo Tech® multi-activation bypass valve made it possible to have continuous pumping throughout the operation.

The clean-out pills were displaced by pumping inhibited NaBr brine. Clean-out criteria of three consecutive samples of solids content < 0.05% were met after an over-displacement of the theoretical hole volume by 50m³.

RESULTS

The displacement from INNOVERT NS to brine and clean-out operations were a success, insofar as maintaining well integrity. The job was also performed in a very safe manner, with zero HSE incidents and zero non-productive time (NPT) incurred. Halliburton Baroid provided and executed fluids that gave the necessary overbalance throughout displacement, avoided swabbing, and followed an updated tripping schedule from the AFO services when POOH after displacing to brine. The avoidance of potential overbalance scenarios was due to TETRA CS Neptune brine helping to manage the displacement and clean-out in a way that did not harm personnel or the environment. Cleanliness criteria were met and, after completion of the well, most of the brine was sent to shore for cost-efficient reclamation and re-use.

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