Society of Petroleum Engineers

S P E 30433
Successful Drill Cuttings Re-injection (CRI) Case History On A Subsea Template Utilizing Low Cost Natural Oil Based Mud

J. Reddoch, SPE, Apollo Services, and C. Taylor, British Gas, and R. Smith, SPE, Consultant

This paper was prepared for presentation at the Offshore Europe Conference held In Aberdeen. Scotland UK 5-8 September, 1995.

Abstract

This paper covers the drill cuttings re-injection engineering and operating techniques utilized by British Gas and Apollo Services, on the three year Tunisian Miskar project off the coast of Sfax, Tunisia. At the time of this writing, British Gas has completed the sub-sea template phase, including the drilling and cuttings injection on 9 wells. A platform was installed in the last quarter of 1994 and the second drilling phase of this project began in March of 1995. A total of 11 or more wells are planned over a 3 year period.

Environmental regulations prohibited the dumping of oil based mud in the sea. Thus, if British Gas wanted the high penetration rates and, limited hole problems achieved by utilizing low cost, natural oil based mud, then cuttings re-injection presented the cost effective alternative.

All waste, from 8 wells, has been successfully pumped down three of the annuli with great success. Insignificant downtime has been experienced due to the injection process, even at instantaneous penetration rates in excess of 200 meters per hour on 12 1/4 inch hole. The CRI contractor rigged up and operated, with one man per 12 hour tower, the cuttings transfer system, the cuttings grinding/slurrification system and the triplex pump cuttings injection system. Over 2000 meters of limestone/claystone was encountered in each well while drilling and injecting successfully, (in the frac mode), into an impermeable claystone formation.

Addressed in this paper are:

1. Well Planning with information on template drilling as it relates to cuttings re-injection.
2. Injection well disposal design and planning, including multiple well casing points, for development drilling while producing.
3. Requirements for surface equipment, personnel and commissioning.
4. Field Results and Data with adjustments for unplanned events.
5. Economics of CRI and natural oil base verses synthetic (psuedo) oil mud.
6. Conclusions and recommendations for future work.

Introduction

The Miskar project is located 75 miles ESE of the coast of Sfax, Tunisia **(Fig. 1)** of Northern Africa. The Tunisian Government mandated zero discharge of oil. The targets required drilling directionally thru highly reactive formations. These formations are most economically drilled utilizing natural oil based muds. A significant savings was foreseen utilizing natural oil base mud with successful Cuttings Re-injection to drill the wells, as opposed to utilizing water base or synthetic (psuedo) oil mud.

The project called for drilling 11 or more directionally drilled wells over a 3 year period **(Fig. 2)** commencing in the 1st quarter 1993. The first 8 wells were drilled and temporarily plugged via a jack-up over a template, while the platform, pipeline and onshore processing facilities were built. All of the wells utilized mud line suspension hanger systems. The platform was installed in the last quarter of 1994. A jack up rig was moved back onto the platform to tie back the first wells for production. As of the writing of this paper, tiebacks have been completed and simultaneous production and drilling operations are in progress.

To date, all liquids and cuttings have been disposed of with no discharge to the environment and/or plugging or breaching.

This paper is comprised of 7 sections. **Introduction, Well Plans** provides details of well plans, with information on template drilling as it relates to cuttings re-injection. **Injection Engineering Specifications** provides specific design criteria of the wells for successful cuttings injection gas in the intermediate casing. Burst on the surface casing was the limiting component. The risers were designed for freestanding use, with no axial tension in site specific weather environments. Due to the actual fracture pressures required, we ran stronger surface casing on subsequent wells, to increase the safe working pressure to 3500 psi.

Area Faulting

The. area was reviewed for faults and fractures. None were evident in the preplanning survey and none were encountered in the actual operation.

Erosion Contingencies

A standard well head (Fig. 12) and mud line suspension system was chosen for the project. The CRI contractor surveyed the openings of the mud line suspension hanger to make sure that erosion would not degrade the strength of the system and to make sure that there was an adequate opening to convey the slurry without plugging. It is standard policy not to inject over 3 BPM and usually to inject at 1.5 BPM. At these rates sand erosion velocities (200 feet/min.) are not reached and no problems were anticipated with either the well head, intermediate string or with the mud line suspension system. Since we grind cuttings to less than 100 microns and use the proper rheological control, we were not concerned with plugging the openings of the mud line suspension system. After the risers were pulled and inspected, no erosion was noted in any of the equipment.

Well Permitting

The Tunisian Government was open to cuttings re-injection as a disposal alternative. The plans of disposal were approved with the plan for exploration and development. Standard requirements for safe injection were outlined in the plan (Fig. 13).

Data Acquisition

A critical element in drill cuttings re-injection is accurate real time data collection, timely analysis of data, knowledgeable listening to the hole and quick response to danger signals. The following form was used for the injection project (See Fig. 14). Data collection was used to improve the injection operation and to prevent plugging/breaching throughout the project. Based upon this data, modifications were made to the casing program on well #3 and to the pumping methods (continuous vs. displacement).

Surface Equipment Considerations

British Gas required one conductor to supply comprehensive cuttings injection services, i.e. catching, collecting, conveying, grinding, slurrification, and injection of the cuttings. There was no allowance for adding personnel or equipment, at the operators expense to adequately perform the contract.

Three areas of concern for British Gas was:

1) The ability of the contractor to process the cuttings and inject them as fast as the rig generated them, without slowing or shutting down the rig.

2) What particle size would be achieved that would not plug or breach the formation?

3) Would a mill be required for grinding the limestone fine enough or would the CRI contractors modified centrifugal pump degrade the particles adequately?

Little work had actually been done successfully with mills. The majority of the hole was limestone, but the smaller hole sizes and penetration rates thru the limestone limited the quantity and process rates of limestone to be ground. The CRI contractor had a proven mill to back up it's modified centrifugal pump (CSP) design thus providing a contingency for un-grindable solids. The contractor's mill was to be provided after the first well, if the CRI contractor could not grind the limestone cuttings fine enough at required process rates.

To meet the requirements of the contract, Apollo provided the following equipment flow diagram (Fig. 15 and 16). The cuttings are transferred by the screw conveyors to the cuttings slurry unit. One Apollo centrifugal shredding pump (CSP) is designed to grind all cuttings, including the limestone. The other CSP pump is for back up only, which gives the system 100 per cent redundancy. The cuttings slurry is passed across a positive shaker and any cuttings ground fine enough, pass thru the screen and are gravity fed to a holding tank. Any cuttings which are not ground fine enough are automatically sent back to the first CSP for further grinding. Cuttings slurries under 100 microns are then injected down hole by the Triplex Injection Pump.

The design of the CSP units provides for an extremely high rate of grinding. It is this grinding capability that provided fine particle size slurries, passed 100 per cent thru an automatic sizing system, even at high drill rates (Figs. 17 and 18).. Without a high grinding rate the solids would build up in the first tank shutting down the entire system. If the shaker was bypassed or not used as is in other systems, then the injection formation and annulus becomes “at risk”.

5. Manning requirements and downtime can be minimized with a properly designed and commissioned system.

6. Claystone formations accept the waste slurries as long as . the injection well is properly designed to continue forcing the fractures and particle size/rheologies are carefully controlled. Continuous injection methods should be utilized and water minimized on these type formations.

7. 300 meter displacements are adequate for protection against communication between the injection formation in claystones and other well paths.

8. Oil base mud with CRI is very economical compared to synthetic (psuedo) oil mud on this type of project.

9. Given the same drilling practices i.e., rig solids control, triplex pumps, drill pipe, personnel, etc.; drill rates with natural oil base mud can mirror drill rates with synthetic (psuedo) oil mud.

10. Rig cement pumps are adequate for planned back-up to the triplex injection skid.

Acknowledgments

The authors would like to thank the managements and staff of British Gas Exploration & Production, Phillips Petroleum and Apollo Services for their total support of this project initiative. Significant "team" assistance was afforded by the drilling engineering and operations groups of British Gas Exploration and Production, the Apollo operations team and all personnel associated with the rig/well operations.

Reference 1. Louviere, R.J. and Reddoch, J. A. "Onsite Disposal of Rig-Generated waste via Slurrification and Annular Injection", paper SPE 25755 presented at the 1993 SPE/IADC Drilling Conference, Amsterdam Feb. 23-25. 2. Malachosky, E., et al "Offshore disposal of oil-based drilling fluid waste: An environmentally acceptable solution." SPE paper 23373. First Cong. Int. on Health, Safety & Environment, 1991.

3. Bailey, T.J., Henderson, J.D., and Schofield, T.R., "Cost effectiveness of oil-based drilling muds in the UKCS." SPE paper 16525/1. Offshore Europe, 1987.

Metric Conversion Factors

1 barrel (bbl) = 0.1589 m3 1 foot (ft) = 0.3048 m .345 pound per gallon (ppg) = 1000 kg/m3 1 pound (lb) = 0.453 kg 1 pound per square inch = 0.069 Bar