Installing cuttings reinjection systems on Shell/Esso platforms

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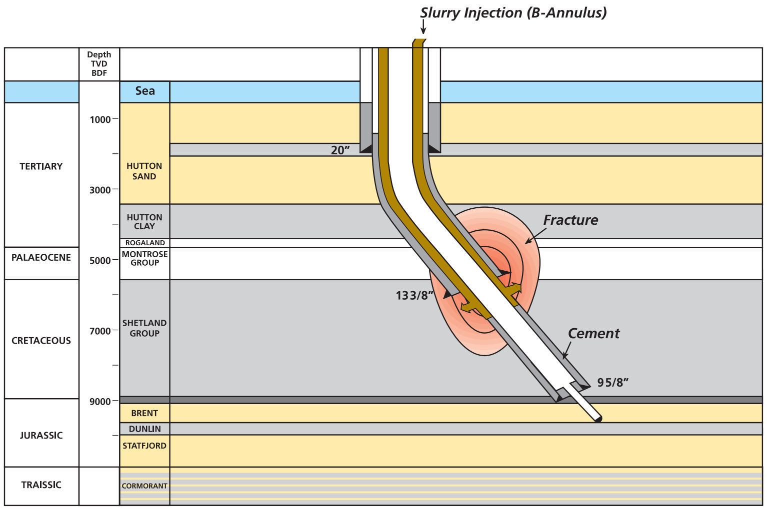
THE UK DEPARTMENT of Trade and Industry's targets for cuttings disposal require all operators to have a phase-out schedule by 31 Dec, 2000, to eliminate the discharge of mineral oil-based cuttings. Some companies have moved to synthetic fluids, but DTI studies show that synthetics do not biodegrade any better than mineral oils. They too may be phased out.

To be proactive, **Shell UK Exploration and Production's** (**Shell Expro**) Northern Business Unit (then consisting of North Cormorant, Cormorant Alpha, Dunlin, Tern and Eider) elected to advance this 31 Dec, 2000, deadline one year—to 1 Jan, 2000. (Shell Expro is operator in the UK sector of the North Sea for **Shell**, **Esso** and other co-venturers.)



KCA Drilling determined that reinjection was the optimum method to achieve total containment of mineral-oil contaminated cuttings. After revamping platform topsides to accommodate injection equipment, the team selected the recipient formations. More than 100 existing wells were screened to identify test candidates. Reinjection began in earnest in 1999 and has proven successful.

KCA Drilling, the drilling contractor for the Shell Expro NBU, was given the task of identifying and installing the best and most economical method of total containment. KCA's 1997 feasibility study clearly showed cuttings reinjection (CRI) to be the preferred option, vs shipping of cuttings to shore for treatment and disposal.

The detailed project work began mid-1997 and consisted of topsides work and subsurface work carried out in parallel. 3 CRI plants have now been installed and commissioned on the North Cormorant, Tern Alpha and Dunlin Alpha platforms.

TOPSIDES

A site survey was carried out on the 3 platforms in July 1997. The survey personnel consisted of a multi-disciplinary KCA engineering team supported by an experienced engineer from vendors supplying total containment equipment. The conceptual design survey assessed spatial requirements, weight constraints, access limitations, impact on other platform operations, tie-in to existing solids control equipment, structural modifications and power and utility requirements. As deck space is always at a premium, the task was to retrofit the equipment into the mud treatment skid, which would also make cuttings transportation much simpler.

Conceptual design followed. This addressed the scope of work, basis for design, description, design, installation workscope, shutdown requirements, outstanding items/areas of concern, equipment lists, drawings, calculations, cost estimating/planning, specifications and vendor data. The conceptual design report was issued in November 1997.

Tendering for the CRI equipment then took place. Following bid evaluation, award for the 3 sets of equipment was made to **Swaco** in December 1997. The slurrification equipment was based around the **ARCO** principle of using modified centrifugal pumps for degrading the cuttings and making seawater slurry. Additional equipment consisted of a shaker classifier for guaranteeing the 300 micron particle size, a secondary mill for grinding the hard lithologies and the triplex injection pump with DC motor drive for pumping the slurry down the disposal well.

Detailed design and procurement of materials were the main activities for most of 1998. Offshore construction and installation of the CRI equipment took place from November 1998 to January 1999.

Commissioning of the CRI equipment on the 3 platforms in early 1999 finished the topsides work in the project.

SUBSURFACE WORK

In parallel with the topsides activities, certain subsurface work was required to provide suitable CRI wells on each of the 3 platforms by the time the units were commissioned and operational CRI commenced.

Selection of the recipient formations: Initially, the annuli in existing production and water injection wells were examined to see if an injection pathway to the formation could be found. There was insufficient time to wait for new wells to modify into disposal wells.

It was found that the only formation window available was via the $9\frac{5}{8}$-in. by $13\frac{3}{8}$-in. annulus, which exposed the formation between the $13\frac{3}{8}$-in. casing shoe and the top of the $9\frac{5}{8}$-in. cement. The formations were the intermediate depth (5,500 ft vertical) clays of the Hutton, Montrose and Shetland. This was a safe depth to fracture and inject cuttings slurry without the risk of intersecting the hydrocarbon reservoirs or the seabed with the fractures well away from the platform.

Screening for potential test wells: Over 100 existing wells were screened in order to find suitable candidate wells for testing. Any problems identified in the screening would disqualify a well from consideration. The screening criteria used were: evaluation of the location and quality of the cement outside the casing, proximity of near-by wells in relationship to the predicted fracture path, calculation of the casing strengths with allowance for erosion and corrosion and other factors.

Donor well data: Hole sections to be drilled with oil-based mud on each platform up to the year 2004 were provided by Shell Expro and slurry volumes to inject were calculated.

These ranged from 40,000-130,000 bbl on the 3 platforms and included a 25% allowance for the disposal of other drilling wastes (drains, washwater, overflush for the annulus and spent mud).

Fracture modeling study: Mechanical and rock property data for the study was assembled. Shell Expro conducted the study using a PSEUDO-3D programme, which modeled a planar single fracture, starting from the small initial fracture and progressing vertically through the different formations (up to 10 layers).

The outputs of the model were:

• Predicted fracture geometry;

• Fracture length vs volume injected;

• Worst-case slurry volume allowed per injection well;

• Maximum injection pressure required;

• Optimum slurry density to produce.

The modeling predicted that there was no risk of injecting up to 150,000 bbl of fluid per injection well mainly due to the massive porous Hutton Sand above the clays, which would stop the fracture. A joint Shell Expro and KCA Report was issued in October 1998 and formed the basis for DTI approval.

Programming for injection testing: Programmes were written to conduct extended leak-off tests on the candidate injectors. Each platform had a ranked list of candidate wells. Testing would continue until a maximum of 4 successful tests were performed. Injection volumes ranged from 300-900 bbl.

The objectives of the tests were to:

• Confirm that an open pathway to the formation actually existed, and that the clays would fracture (uncertainties in the effect of barite settlement, cement stringers or damaged clays would mean that not all candidate wells would fracture);

• Provide data which would refine the PSEUDO-3D fracture model to better estimate fracture geometry / behaviour.

Injection testing: Following delivery of testing equipment and the arrival of testing personnel, the wells on each platform were tested. Tests took place from March to June 1998. Results secured 2 injectors for North Cormorant and 4 for Tern Alpha. Due to older damaged formations on Dunlin Alpha, no wells would fracture. Subsequently, a suspended well on Dunlin was converted and pre-fractured to make a dedicated injector by going down tubing and through perforations.

On a 4th Shell Expro NBU platform, Cormorant Alpha, topsides work to install CRI will not start until January 2001, but the subsurface work has been completed. Testing on Cormorant Alpha candidate injectors was carried out in December 1998 and 4 wells were successfully fractured for future use.

Presentation to DTI: In October 1998, a presentation was made to representatives of the DTI summarising the fracture-modeling results. DTI were interested in the fracturing technique, volumes planned for injection into any one injection well and the size of the fracture system created, to guarantee the fracture didn't propagate into any high-risk areas.

CRI operating procedure: A comprehensive cuttings reinjection operating procedure was issued in January 1999 for the use of the offshore management and the Swaco operators of the CRI plant. A few of the many subjects in the manuals are:

• Routine injection procedures using the equipment;

• Slurry specifications required;

• Annulus management procedures;

• Slurry displacement requirements;

• Responsibilities of onshore and offshore personnel;

• Contingency planning;

• Data collection;

• Reporting the chemicals required.

CRI OPERATIONS

The CRI systems became operational on North Cormorant in January 1999 and on Tern Alpha in June 1999. The Dunlin equipment is commissioned and ready for use; however, no drilling is planned on the platform until circa January 2001. Apart from the normal breaking in of new plant and minor modifications, the objective of zero discharge of oily cuttings to the sea has been achieved on North Cormorant and Tern Alpha.

ABOUT THE AUTHOR

Byron Secoy *holds an MSc degree in petroleum engineering from the* ***University of Southern California****. He has worked worldwide in a variety of engineering and management positions for over 30 years. Since 1990 he has specialised in cuttings reinjection. He has been a consultant with* ***KCA*** *since 1997 on CRI subsurface engineering.*