

UBD drilling successful in Middle East wells

IN THE PRESSURE depleted section of Occidental's Safah Field in Oman, use of conventional overbalanced drilling techniques resulted in complete lost circulation of drilling fluid, differential sticking of the drill string and inability to drill horizontal sections.

Underbalanced drilling techniques were successfully utilized to add horizontal lateral sections to existing wells, complete the Shuaiba Carbonate Reservoir waterflood pattern and increase Safah Field production.

To complete the waterflood pattern, it was required that dual horizontal lateral sections be drilled in the existing Safah 158 and Safah 170 wells.

In July 2000 the Safah 170 well was drilled. The well was programmed to have two horizontal laterals drilled into the Shuaiba Limestone using a conventional overbalanced drilling fluid system.

Due to Shuaiba Reservoir pressure depletion in Safah 170, complete lost returns and differential sticking of the drill string occurred while attempting to drill horizontally.

Attempts to produce Safah 170 were unsuccessful and the well was shut in.

The Safah 158 well, a single lateral horizontal, was drilled in 1998. Safah 158 is also in the pressure-depleted section of the Safah Field Shuaiba limestone and was producing 200 BOPD prior to reentry to add two drilling horizontal lateral sections.

In midyear 2000 an engineering study was conducted to evaluate the feasibility of using underbalanced drilling techniques to add required horizontal lateral sections to Safah 158 and Safah 170 wells, so that the Safah Field waterflood pattern could be completed.

In late 2000 and early 2001 underbalanced drilling techniques were utilized to drill horizontal lateral sections in the Safah 158 and Safah 170 wells to complete the Safah Field waterflood pattern.

With the added horizontal laterals, Safah 158 production has increased from 200 BOPD to 800 BOPD. With the addition of horizontal laterals, Safah

170 (which initially was nonproductive and was shut in) now produces 1,500 BOPD.

To complete the Safah Field Shuaiba reservoir drain pattern, horizontal laterals were required in the pressure depleted Safah 158 and Safah 170 wells. Underbalanced drilling modeling for these two wells was conducted.

Underbalanced drilling techniques were successfully utilized to add horizontal lateral sections to existing wells, complete the Shuaiba Carbonate Reservoir waterflood pattern and increase Safah Field production.

Safah Lease crude (42 degree API) was selected for the underbalanced drilling fluid.

Pumping lease crude and lease gas as a two phase fluid system down the drill string was considered but rejected due to additional costs and limited availability of a gas tight Kelly hose, plus the additional costs and limited availability of electronic telemetry MWD tools.

Modeling predicted that underbalanced drilling conditions could be achieved by utilizing a single phase drilling fluid (lease crude), and using gas lift in the drill string annulus.

The use of nitrogen for a drilling fluid was considered and rejected due to high cost and limited availability.

To reenter and drill underbalanced horizontal laterals in Safah 158 and Safah 170 using lease crude, annular gas lift of the drilled cuttings was required.

Drilling rig equipment and layout were surveyed with consideration for compatibility with the underbalanced drilling package.

Stack up heights associated with an additional wellhead spool to hang off the 7-in. parasite casing string and the additional height and flow line requirements for a rotating BOP were checked.

Safah crude was analyzed and compatibility with all equipment utilized in the underbalanced operation was confirmed.

Underbalanced drilling HAZOP studies were conducted with involvement from the operator, drilling personnel, operator HSE personnel, operator production personnel and all associated contractors.

Specific procedures were written for killing the well, making drill string connections while drilling, trips and wiper trips.

For well control considerations kill weight brine was stored in the drilling rig mud tanks.

APPLICATION OF EQUIPMENT AND PROCESSES

It was decided to utilize the underbalanced drilling package first on the normally pressured horizontal section of the new Safah 175 well to test the equipment and set up, then reenter and drill horizontal lateral sections on Safah 170 and Safah 158 wells.

Safah 175 was drilled underbalanced with Safah crude. Since the new Safah 175 well was drilled in a non-pressured depleted Shuaiba limestone area, gas lift was not required or utilized during underbalanced drilling of the Safah 175 "shake down" well.

The crews became familiar with the underbalanced drilling equipment and procedures while drilling the well.

Prior to the start of the underbalanced drilling operations at Safah 175 a two-day safety-training course was conducted for all associated personnel.

Extensive on-site safety meetings were held to familiarize all associated personnel with each non-routine operation.

Fire fighting equipment, gas detection and gas alarm units were installed.

The underbalanced drilling operation was a zero discharge operation. Cuttings were bagged for processing. A dripless mud bucket and drip pans were installed. All fluids were routed to capture tanks.

For the three-well underbalanced drilling project, a choke manifold and a four-phase separator were used downstream of the rotating BOP. Produced gas was burned using a flare stack.

Produced crude was centrifuged and routed through a hooded shale shaker.

Produced crude required for drilling was pumped back through the drill string using the rig pumps.

Crude was pumped down the drill string at 250 gpm. Surplus produced crude was stored in an onsite tank battery and then pumped to the Safah production facilities.

On the Safah 170 and 158 pressure depleted reservoir wells, a parasite 7-in. casing string was run to 10 ft above the 7-in. liner hanger.

Seven inch casing slips and a surface wellhead pack off for the 7-in. parasite string were installed.

Safah lease gas was injected down the 9⁵/₈-in. production casing by 7-in. parasite casing annulus and up the 7-in. parasite casing by 3¹/₂-in. drill string annulus.

Hole cleaning procedures were established to eliminate cuttings beds.

Before each connection and before and after trips, 5 barrel slugs (60 viscosity, 15 yield point) were pumped.

These slugs were 60% crude, 37% fresh water and 3% by volume ester-based lubricant.

For lubricity considerations, fresh Safah crude was added to the Safah crude drilling system to reduce detrimental effects of drilled solids build up.

With 12 hours of continuous drilling the API gravity of the crude drilling fluid was reduced from 41 to 39.

The underbalanced drilling package was released from Safah 158 in March 2001.

DATA AND RESULTS

A surface read out 'real-time' bottom hole pressure tool was run on Safah 170 and Safah 158 reentries during the horizontal lateral drilling operations.

The real time bottom hole pressure was monitored. Circulating parameters were

adjusted to achieve underbalanced conditions.

At times balance condition and slightly overbalanced conditions occurred while drilling.

Production from Safah 158 and Safah 170 has increased 600 BOPD and 1,500 BOPD, respectively, after adding the horizontal lateral sections.

In the process of drilling the horizontal laterals, instantaneous crude production rates of up to 6,500 BOPD were recorded and gas production rates of up to 10 MMscfpd were recorded.

No differential sticking was encountered while drilling the horizontal lateral sections in Safah 170 and Safah 158.

Instantaneous rates of penetration of up to 1,000 feet per hour were recorded while drilling the horizontal laterals.

Maximum instantaneous rates of penetration in lateral sections drilled with conventional overbalanced systems in the Safah Field Shuaiba Formation have been in the range of 300 feet per hour.

By utilizing underbalanced drilling techniques Occidental was able to add two horizontal lateral sections to Safah 158 and two horizontal lateral sections to Safah 170.

Production from Safah 158 and Safah 170 has increased 600 BOPD and 1,500 BOPD, respectively after adding the horizontal lateral sections.

A secondary objective of underbalanced drilling is the improvement in productivity due to reduction or elimination of possible formation damage associated with conventional (overbalanced) drilling techniques.

It was not certain how the Shuaiba Carbonate reservoir would react in the underbalanced drilling mode.

A learning curve was established while the underbalanced drilling program progressed.

Initially, hole cleaning was a major problem, however, the problems were resolved by making frequent short (five stand) wiper trips and the pumping of

viscous slugs before and after the wiper trips.

Hole cleaning was difficult on the shake out Safah 175 well. This well did not have annular gas lift or the 7-in. parasite string run.

Cuttings were transported up the large 9⁵/₈-in.x3¹/₂-in drill pipe annulus.

Well tests of the Shuaiba, of wells that were drilled overbalanced, indicate zero skin damage after clean up.

Reduction of skin damage was not a specific objective in this underbalanced drilling program.

The daily drilling package spread fixed costs with the underbalanced drilling package added was \$45,000.

Daily drilling rig package spread costs without the underbalanced drilling package was \$22,000.

The cost per foot for drilling the horizontal lateral section conventionally and underbalanced are \$75 and \$125 respectively.

Safe operation procedures and good work practices were executed, and no lost time accidents (LTA's) occurred during the underbalanced drilling operations.

The use of underbalanced drilling techniques in the Shuaiba Carbonate pressure depleted reservoir section of the Safah field was successful and enabled Occidental to complete the waterflood pattern in that area of the field.

Without underbalanced drilling, according to Occidental, it would have been impossible to drill the additional laterals.

Production from the underbalanced drilled horizontal lateral sections to Safah 158 and Safah 170 wells increased the Safah field production by 2,100 barrels per day.

REFERENCE

This article was adapted from an IADC/SPE paper "Recovery of Lost Reserves Through Application of Underbalanced Drilling Techniques in the Safah Field" by Mark C Stuczynski, PE, with Occidental Oil and Gas Corporation. ■