Horizontal UB achieves production improvement

THE HUGOTON FIELD in the Texas Panhandle is one of the largest gas producing fields in the lower 48 states. Until recently, these shallow reserves have been exploited by drilling either vertical wells with air or long reach horizontal wells with conventional overbalanced techniques. Due to the low formation pressures, in the range of 600 psi, depletion is a major issue and wells drilled in conventional overbalance have not exhibited a consistent productivity trend.

These low pressures have also resulted in severe lost circulation problems during drilling with resultant formation damage and productivity deterioration. An additional challenge has been the close proximity of water to the productive formation, which effectively eliminates the use of fracturing as a stimulation option.

Previously, wells were drilled vertically using underbalanced techniques (UB) but the limited kh that resulted had little positive effect on productivity. Nevertheless, the operator decided to drill three horizontal wells using UB, as a case study to make a definitive evaluation of its effectiveness in the Hugoton Field. All three wells were successfully completed and achieved a significant increase in production when compared to offset wells drilled conventionally. The results achieved were of added significance considering the low cost environment in which the wells were drilled, where use of conventional techniques typically resulted in marginal economics.

The risk of encountering lost circulation zones has increased as drilling has continued. Reserves have diminished making the economics of the planned wells more stringent. As a result the associated well costs are rigorously scrutinized to meet or pass required economic standards.

The addition of one or two extra days between spud and rig release, due to curing losses in shallow depth wells, may increase well cost by 20% to 30%, which is significant with the tight economic margins.

BP and **Weatherford** developed a program to drill three wells in the Courson Ranch area to determine the technical and economical feasibility of applying underbalance horizontal technology in the Brown Dolomite formation. If successful, this would improve the reservoir performance and extend its life while maintaining economic objectives

RESERVOIR DESCRIPTION

The Courson Ranch is located in the Northwestern portion of Roberts County, Texas. The reservoir portion of the lease encompasses about 15 square miles. The reservoir is a Wolfcampian Platform Dolostone informally called the Brown Dolomite, which is approximately 250 ft thick with a net reservoir thickness of only 20 ft. The trap is mainly structural, with a stratigraphic pinch-out to the north, the overlying anhydrite forming the seal.

The current flowing and static formation conditions were determined from one of the existing producing wells to evaluate the efficiency of using the underbalance horizontal drilling techniques. Flowing gradients and pressure build up data was obtained using slick line conveyed electronic pressure gauges. The data was modeled assuming a homogenous reservoir and log/log and semi-log analysis were used to interpret the data.

PREVIOUS WELLS

Many wells were drilled initially for deeper horizons and a significant number of these wells experienced losses to the Brown Dolomite formation in the order of hundreds of barrels of water based mud.

Some other areas of the Hugoton field have been drilled with the Brown Dolomite as a target using the following designs.

Vertical underbalance. Wells were drilled to the top of the reservoir in 7 ⅞-in. hole size. Water-base drilling fluids loaded with LCM to prevent losses were used to drill into the Dolomite and 5 ½-in. casing was run.

Cement slurries were sometimes nitrified to improve the success of cement jobs. About 200-300 ft of pay were drilled underbalanced with air-misted fluid, the rig would then move off location and the formation stimulated with water fracs.

The wells were completed initially with slotted liners but later were completed “bare foot”, based on rock strength analysis (RSA) and the fact that historic operational analysis indicated that the formation was competent enough to remain open over time. Production results were relatively consistent but still low, causing concern that the projects were at risk of being unable to meet the economic requirements.

Vertical Overbalance. Two wells that were completed in the Brown Dolomite formation were drilled vertically with conventional water-base mud and high concentrations of LCM (i.e. cotton seed hulls and cedar fiber in the order of 16 ppb). The wells were drilled with a similar design, 12 ¼-in. hole to approximately 1,500 ft with 8 ⅝-in. casing and then 7 ⅞-in. hole to 5,600 ft with 4 ½-in. casing being set.

After log evaluation, they were completed using 2 ⅞-in. tubing. Due to water proximity concerns, the formation could not be fracture stimulated, thus reducing the potential deliverability.

Horizontal Overbalance. A similar wellbore design was used, with 5 ½-in. casing set in the top of the pay and then the lateral drilled overbalance in 4 ¾-in. hole. However, while drilling the lateral, several hundred barrels of fluid was lost. The results were mixed: one did not produce and the other proved to be uneconomical, resulting in discontinuation of the program.

UBD PLANNING STRATEGY

The Courson Ranch area was selected to perform the initial three-well trial because of the higher potential for success that drilling underbalance in this area presented. The main reasons were the relatively high reservoir pressure regimes encountered in the Brown Dolomite formation and the experience gained from the extensive drilling of underbalance vertical wells in the area.

After a failed attempt to drill the wells using coiled tubing (CT) techniques, the decision was made to try underbalance horizontal drilling techniques using a conventional rotary drilling rig. During the planning process, all of the initial HAZIDS sessions and peer review information was taken into consideration.

This helped to identify and deal with potential obstacles that may have jeopardized the success of the UB horizontal project.

A multidisciplinary team was established with representatives from the BP resource team, BP drilling (Houston and field based personnel) and Weatherford UBD. This group met on a weekly basis to discuss, define and follow up on the progress of the drilling program to assure that deadlines were met. Regular meetings were also held with the field supervisory personnel to address operational and health, safety and environmental issues.

Once the design was finalized, the next step was to select a rig that met BP's standards and well objectives. Prior to moving to location, a TRUE training (Training to Reduce Unscheduled Events) was conducted with rig crews and personnel of all other company's involved in the project.

This session was designed to discuss the horizontal underbalance drilling program and reemphasize the importance of BP's HS&E policies during critical operations.

WELLBORE DESIGN

Planning a grass root well allowed the flexibility to design the most appropriate hole size likely to increase the chances of successfully drilling the lateral underbalanced section. It was important to drill the lateral section in the top 10 ft of the pay in order to stay away from the water contact.

After running simulations of torque and drag, hydraulics and considering operational issues, it was determined that drilling a 6-in. hole in the pay zone would allow the use of 3 ½-in. drill pipe rather than the 2 ⅞-in. tubing required to drill in a smaller hole size.

The use of 3 ½-in. drill pipe presented several advantages, including the increase of pulling abilities to cover for any unscheduled events such as stuck pipe, higher torque capability, lower frictional losses, ability to transmit WOB, etc., all of which would contribute to longer lateral reach if it was deemed necessary.

Reservoir simulations using the Single Well Seamless Simulator SWSS 2000 determined that the optimal lateral length for these horizontal wells would be about 1,200 ft, a length that should achieve the production rates needed for economic success.

Wellbore stability was a concern on top of the Brown Dolomite. Shale sections above the pay required casing to be set to prevent exposing them to underbalance conditions. It was planned to land a 7-in. intermediate casing string on top of the pay zone.

The first Courson Ranch well was drilled to 836 ft in 12 ¼-in. surface hole and 9 ⅝-in. casing was run. An 8 ½-in. pilot hole was then drilled vertically to 3,682 ft and the well was then logged to get more geological control over the top of the pay.

This would allow for any adjustments that would need to be made to the directional program. An open-hole inflatable packer was then run above the targeted pay zone to support the kick off cement plug that otherwise may have been lost in the hole due to the low formation pressure. The well was then kicked off with an 8 ½-in. bit to a point 5 ft above the pay at 78° at 3,774 ft MD/3,771 ft. Then, 7-in. casing was run and the lateral portion of the well drilled UB in 6-in. hole size to 4,905 ft MD/3,489 ft TVD at 90°.

The subsequent wells were planned with no pilot hole in order to improve performance and reduce costs.

FLUID SELECTION

Based on previous experience in other areas of the Brown Dolomite, it was clear that water-base fluids were compatible with the formation. The areas where wells were vertically drilled with air were later fracture stimulated with water fracs, which reduced costs and showed results similar to other frac techniques. All this evidence indicated that water was the preferred liquid phase of the drilling fluid.

The option of air versus nitrogen was discussed and analyzed during the HAZIDS sessions. Due to the wells being at shallow depths and the low pressure, low temperature and low cost environment, it was decided that an aerated fluid would not compromise safety and would provide an efficient system for hole cleaning and bottom hole pressure management.

Based on this discussion and hydraulic modeling results, it was decided to drill with aerated water mixed with small volumes of foamer to assist with hole cleaning. The corrosion inhibitors were selected to provide superior protection in a fluid stream with high concentrations of oxygen.

The choice of these fluids (water and air) was made due to the fact that conventional mud rheologies are not required for hole cleaning in a two-phase circulation system as a turbulent system is inherently created.

Therefore, to balance the needs of a low bottom-hole pressure and effective hole cleaning, low rheology liquids that are compatible with the reservoir could be used for this specific application. There were no signs of hole drag or poor hole cleaning on any of the Courson Ranch UB horizontal wells.

SURVEY

With drill pipe injection and after modeling the two-phase hydraulics, it was determined that conventional MWD could not be used since the fraction volume of air required to meet target bottom hole circulation pressures exceeded the operating ranges of all available tools.

The uncertainty of electromagnetic MWD performance in the area and the presence of Anhydrite made this an option to be evaluated for the near future but not for the three well trial.

Wire line wet connect, albeit old technology, was in common use in the area and despite being time consuming and operationally more complicated, was selected for its ability to transmit despite the two-phase environment. It proved to be an effective, economic option as the project progressed and crews worked together to minimize connection times.

TWO PHASE FLOW MODEL

During planning operations, a feasibility study was prepared by Weatherford's UBS engineering department to simulate the best combination of injection rates to maintain target BHCP.

This also took into account the need to achieve the hydraulics and drilling parameters in which the down hole motor would best operate given the casing program, directional plan, bottom hole pressure, expected production rates, down-hole motor operating range and other relevant information.

OPERATIONAL ISSUES

This being the first group of wells drilled underbalance horizontally in the field, lessons were learned from both the directional and underbalanced side as the field and office personnel became more familiar with these types of operations.

Flow model simulation calculations were performed to achieve the targeted draw down of 100 psi to achieve the hydraulics required to properly clean the hole and to provide the motor with the appropriate conditions to operate efficiently.

Underbalance was achieved and wells were drilled flaring straight to the blooie line and waste pit. No signs of excessive drag during trips were observed and the hole was properly cleaned.

Once wells reached TD, trips out of the hole were made flaring gas to the waste pit until surface pressure versus string weight dictated that water be pumped to balance pressures and allow the safe retrieval of the rest of the drill string.

Wet connect was time consuming while drilling the first well, taking an average of 30 minutes per connection, but as time passed it was reduced to 15 minutes per connection on the third well.

The lack of proper solids control equipment on the rig directly affected ROP on the build section. The rig was changed for the wells drilled after this initial trial, addressing solids control equipment. These changes positively impacted the performance in this section.

PRODUCTION RESULTS

Typical UB horizontal wells have exhibited initial rates of about 1,200 Mcf/d compared to vertical wells with initial rates of about 400 Mcf/d. The first group of horizontal underbalanced wells drilled in this area exhibited the expected average rate of 1,200 Mcf/d. Additional benefits include extended well life and increase ultimate recovery

CONCLUSIONS

• Underbalance horizontal drilling in the area has improved the economics of wells drilled in a low-cost environment and, as a result, has created additional business opportunities in more areas of the field.

• The placement of underbalance horizontal wells proved to be an effective way to increase productivity in reservoirs where, due to water vicinity, fracture stimulation is not an option.

• Underbalance horizontal wells have shown initial production rates three times greater than those of vertical wells.

• Underbalance horizontal wells have seven additional years of well life (45% incremental) compared to vertical wells.

• Horizontal Underbalanced wells capture approximately 0.5 BCF additional reserves (70% incremental) when compared to vertical wells. Drilling underbalance successfully prevented the loss of several hundred barrels of drilling fluids into the reservoir, resulting in the reduction and even the elimination of formation damage.

• Once the wells reached TD and the drill string was pulled out of the hole, the well was ready for production. This reduced the completion costs associated with kicking wells off and the time from spud to first sales.

• Perhaps most importantly, this operation, although new for rig crews, was conducted in the safest and most efficient manner possible. The wells were a success not only from the production and operation point of view but also from HS&E aspects. The project was completed accident free and with no harm done to the environment. ■