UBD succeeds in low gravity Brazilian reservoirs

AFTER SEVERAL YEARS of reservoir evaluation followed by several months of planning, **Weatherford UBS** performed four Flowdrill operations in shallow, unconsolidated low gravity reservoirs in northeastern Brazil.

These were the first wells of their kind in Latin America and were considered successful based upon drilling, operational and productivity results.

All four wells were horizontal, with an operating time of less than 10% of the time typically required for a conventional drilling operation.

Investigating production optimization techniques for the shallow reservoirs with high permeability and porosity due to low pressure gradient resulted in evaluating and ultimately applying underbalanced drilling methods successfully, despite the API 11 gravity oil produced from the reservoirs.

The heavy oil with asphaltene and paraffin content has a very high viscosity and water saturation above 60%.

As a result, water-base drilling mud was selected for the drilling operation. Due to the over balance effects and mechanism that occur in low API gravity oil producing zones, underbalanced drilling was applied to minimize the induced damage such as solids plugging, fines migration and emulsion formation and plugging.

The reservoir pressure gradient was in the range of 7.7 #/gal equivalent and the formation collapse was calculated at 6.0 #/gal. In general, the drilling operation was conducted within the narrow window keeping in mind that the total vertical depth was 650 ft.

As a result, minimum influxes during connection time have a significant impact on the bottom hole pressure and generate pressure spikes acting both ways, i.e., slightly overbalance after a connection and below collapse pressure after unloading the hole.

Reaching levels below the recommended pressure window while unloading the hole demonstrated that, while keeping the well in dynamic condition with low pressure gradient, the hole can be maintained and no stability problems would be encountered.

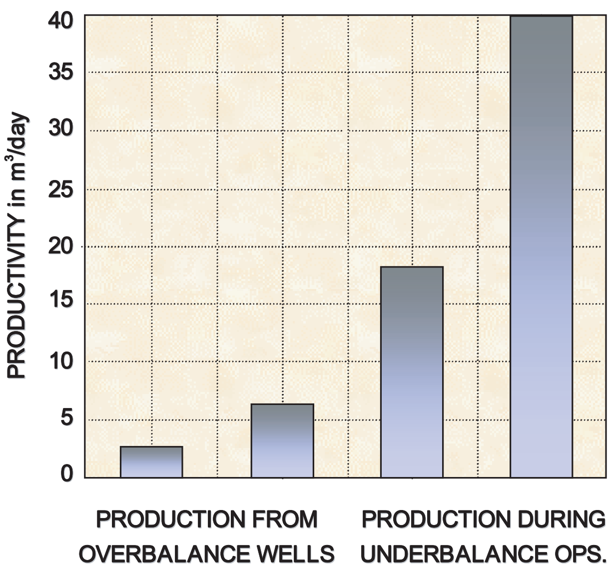
Nitrogen injection into the water-base fluid was used for lifting and lightening the mud column and maintaining it within the operational ranges.

The technology has served as a beginning to corroborate and develop similar reservoirs that have been severely damaged due to drilling fluid invasion as a result of their low pressure characteristics and high permeability and porosity.

OPERATIONAL PLANNING

Since these were the first wells of their kind to be drilling in an underbalanced condition, special attention was given to the operational planning. Planning considerations included:

- The well plan
- Hole stability evaluation
- Drilling fluid
- Gas Applicable
- Surface control and process
- Emulsions formation and oil production
- Optimization of the drilling activity
- Operational training, safety and HAZOP



The well plan called for horizontal wells due to the target formation being uneconomical to reach via directional drilling operations.

They were not accessible with a vertical well design.

HOLE STABILITY EVALUATION

The well plan called for drillng to the top of the reservoir and landing a 9 5/8-in. casing at 86° from vertical.

The build rate was determined at 11.5°/100 ft. The kick-off point was just below the 13 3/8-in. casing set at 100 ft from the surface.

The operator utilized two different methods to evaluate the wellbore integrity and collapse avoidance during drilling.

The liner elastic and poroelastic methods were used, both of which indicated that the methodology applied and the well design considered all provisions.

It was also determined that the regional in-situ field stress is almost hydrostatic. Consequently, the direction of the horizontal section was not an issue since the area is free of tectonic stress.

DRILLING FLUID

The use of a native oil or oil-base drilling fluid was discarded since the reservoir contains more than 60% water saturation.

A polymer type solids-free water-base drilling fluid was selected. The basic characteristics of the fluid were low density of 8.5 ppg and low yield point.

This resulted in surface separation and to avoid solids induction into the large pore throats that have a significant propensity for physical invasion of artificial and drill solids.

The same drilling fluid was used in all four wells as part of the overall program and to optimize costs.

GAS APPLICABLE

Since the reservoir does not have any associated gas production, the addition of a gas to the designed drilling fluid was required to provide the artificial lifting and lowering of the fluid density to the required flow drill condition.

Nitrogen was selected as the injection gas to optimize the possible corrosion problems.

Since the continuous phase was the water-base drilling fluid and a heavy oil influx with low flash point, nitrogen provided an additional safety margin as well as resulting in corrosion protection.

Another consideration was the estimated short drilling time that determined a relatively low gas volume requirement.

SURFACE CONTROL AND PROCESS

Since the field area is low pressure, where the produced formation oil will control the well by itself with the produced fluid level when circulation stops, the most simple surface separation equipment was used.

Surface equipment included a two phase vertical separator with automatic level and pressure control systems and a three stage skimmer system with a total retention time of approximately five minutes for the determined flow rate and influxes.

Three transfer pumps were used for the processing of fluid returns. One was used to transfer the produced cuttings and solids to the rig solids control system. A second unit was used to transfer the drilling fluid back to the rig system and the third pump was used to transfer the produced oil to the transport trucks or storage area.

A complete data acquisition system was used including a read out of the EM-MWD and PWD.

All surface parameters were recorded and stored in the data acquisition system. Monitors were also installed at the Driller's console and for the underbalanced drilling team.

A communication system was also used during the operation.

EMULSIONS FORMATION

In selecting a water-base drilling fluid, Weatherford knew that an oil in water emulsion would be formed but this was considered less problematic than water in oil emulsion with an oil-base fluid.

The emulsion phenomena originated from the formation of high viscosity oil influx and formation sand, silt and fines, in addition to the asphaltene and paraffin components.

Generally, emulsions were not found to be a cause for concern.

Emulsions were encountered at the skimmer tanks but drilling fluid was maintained within acceptable specifications following cleaning of the drilling fluids with the rig's solid control equipment. This meant the four-well batch drilling program would be able to continue and be completed.

The amount of oil produced during the operation was greater than the normal production of other wells in the area.

The average production of the typical well in the area prior to underbalanced drilling varies between 12.6 and 38.8 b/d, depending if the wells include steam injection. The underbalanced wells produced at between 113 b/d and 252 b/d of oil equivalent.

OPTIMIZING DRILLING ACTIVITY

Batch drilling of the wells was selected as part of the economical plan. Previous experience demonstrated that drilling similar overbalance horizontal wells required approximately three days per well.

Based upon this information, the total time to drill four underbalance horizontal wells was estimated at 1.5 days per well. This proved to be a dramatic overestimation as the first well was drilled in 13 hours. Subsequent wells were significantly shorter.

The crews optimized connection time, the separator back pressure was adjusted to minimize the backpressure to the formation and the gas rate was increased. The adjustments made the underbalance condition more stable and circulation spikes that wre registered in the first well were minimized, providing better circulation. This decreased drilling time to between seven and nine hours.

OPERATIONAL TRAINING

Special care was taken regarding drilling crew training, safety and hazardous operations (HAZOP). A two-day classroom training was established for all crews, including drilling, gas injection, surface equipment, directional and operational crews.

During the classroom training, all written procedures were discussed and explained including the well program and its objectives and the applicable underbalanced drilling technology.

All operational safety procedures were highlighted and reviewed including H2S detection, alarms, well control and environmental control, and the appropriate reactions to each.

Additionally, several operational simulations were performed such as connections, changing RCH rubbers, separation, closing the well string pressure control and coordination of operations.

Surface contaminated cuttings and produced oil storage equipment was programmed and available at all times.

An H2S detection system was in place with alarms and masks were in place.

A command center team was responsible for coordination of the operations. Each operation supervisor was a part of the command center team for the evaluation and recommendation of their best employees for the operation.

CONCLUSIONS

A sense of team work was developed and every lesson learned from the operation was applied to subsequent wells to increase optimization.

The operation was maintained as simple as possible considering the complexity of the drilling operation, the low pressure reservoirs, narrow operating window and produced oil characteristics.

The underbalanced condition was applied adequately to maintain wellbore stability during the full drilling and completion operations.

From the production rates obtained during drilling operations, minimal skin damage was achieved compared with production obtained in similar wells drilled in overbalanced operations.

The difference in production rates between a typical well in the area and the underbalanced wells was as much as eight times.

These wells clearly demonstrate the value of underbalanced drilling methods and technology in a heavy oil environment.

Formation damage was encountered in previous wells that was mechanically originated due to solids invasion and possible downhole produced emulsions that resulted in reduced productivity.

REFERENCE

This article is based upon a paper presented at the 2001 Underbalance Technology Conference by Angela Vargas, Roberto Rodrigana and Roberto Huertas with Weatherford.