

Petrobras multilateral wells productive, economic

PETROBRAS HAS BEEN investing in multilateral well technology since 1997, taking advantage of the economics and increased production. Multilateral technology has the potential for increased well productivity and better economics of production development projects.

The economics of a multilateral well include reaching two different objectives from the same well, saving the cost of a subsea tree and one flowline and control line bundle for each pair of geological targets.

The flip side is drilling and completing multilateral wells is demanding in terms of the sophisticated completion techniques, perfect planning of the complex operations involved and a good interaction between the operator and the service companies involved. There is a large penalty for errors.

Petrobras drilled and completed three TAML Level 4 and 5 multilateral wells in the deepwaters of the Campos Basin during the past three years in order to meet the economic and productive levels of the wells. The wells were drilled in the Bonito field and Voador field. Two multilateral wells in the Barracuda field were completed.

TAML classifies multilateral wells from levels 1 through 6. In a level four junction, the hydraulic isolation is provided by cement around the junction. If the cement around the junction does not provide isolation then flow from the annulus of the liner into the main bore will occur.

In a level 5 system, packers are run around the junction to provide the hydraulic isolation between the main bore and the lateral wells.

The level 4 junction type used in the Petrobras wells consisted of a special "hollow" whipstock oriented and set in the main bore casing to open a window, drill the lateral bore from the original bore set a lateral liner and then run the lateral completion. The whipstock is not actually hollow but the inner part is filled with a drillable material.

A special cement slurry is designed for the lateral liner in order to provide an efficient sealing around the junction.

Petrobras used two different types of junction, a milled window system and a pre-milled window system.

LEVEL 4 BONITO WELL

The Bonito field is in approximately 210 m of water in the Campos Basin and produces from a low permeability limestone reservoir. This multilateral completion involved the re-entry into a vertical well and the level 4 junction. A lower permanent window was opened in the 9 5/8-in. casing at 2,331 m to drill an 8 1/2-in. hole to the top of the reservoir. The 7-in. liner was run and cemented at 2,617 m. When this well was drilled a 3 1/2-in. slotted liner was run followed by an acidizing job to remove fluid cake and any possible damage. A standing valve was run

During displacement of the special cement slurry, however, a loss occurred at the liner shoe as the top of the cement slurry was approaching the junction. As a result, the cement slurry never reached the junction.

Petrobras attempted to cement the junction by pumping 26 barrels of cement through the liner top. A 616 ft horizontal section was drilled out of the liner shoe into the reservoir; a 3 1/2-in. liner was run and an acidizing job performed. The rig moved to the milling-through operation to re-establish the main bore access.

Petrobras attempted to recover the standing valve in the lateral and main bore but was unable to retrieve them and the well was put into production.

LEVEL 5 VOADOR INJECTION WELL

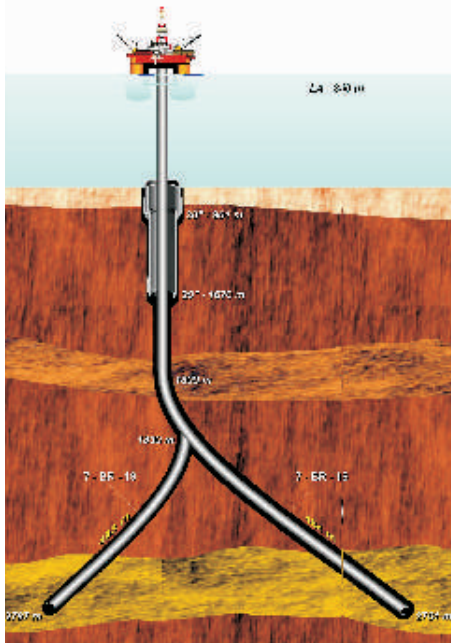
The Voador field is in about 563 m of water in the Campos Basin and contains an unconsolidated sandstone reservoir. The level 5 multilateral with dual opposing laterals was drilled to deliver the desired injection rate while providing maximum reservoir exposure.

The level 5 junction was required to guarantee that no water being injected with pressure would leak into the formation at the junction.

The service companies involved began meeting to plan the well long before it was drilled. The main aspects of the project included the junction building process; a sophisticated completion with the use of screens and sacrifice packers; and hydraulic fully balanced long stroke bumper subs in the string in order to accommodate the heave associated with the semisubmersible during the operation.

The main bore was drilled following common practices for drilling a horizontal well in the area. The 9 5/8-in. casing was run to the top of the reservoir and cemented and an 8 1/2-in. hole was drilled out of the 9 5/8-in. casing shoe through the reservoir.

A screen assembly was installed in the 457 m long horizontal bore and anchored in the 9 5/8-in. main bore casing with a standard seal bore isolation packer. A knockout isolation valve was installed with the packer provided isola-



The level 5 multilateral well in the Barracuda field saved Petrobras the cost of an additional subsea tree and the total length of subsea lines that must be laid on the seafloor.

and set before the well was temporarily abandoned to drill the upper lateral.

The hollow whipstock was then run and set in the 9 5/8-in. casing to open another window for the upper lateral. An 8 1/2-in. hole was drilled to the top of the reservoir where a 7-in. liner string was run and cemented at 2,662 m.

tion of the injection zone prior to running multilateral equipment.

The well proved up the concept of using a multilateral well as a viable alternative for deepwater subsea field development, and has been used as an injector since 1999.

LEVEL 5 BARRACUDA WELLS

Two level 5 multilateral wells were drilling in the Barracuda field, one a milled window system and the other with a pre-milled window system. The Barracuda field is in approximately 800-1,100 m of water in the Campos Basin and required a water injection program.

The purpose was to drill and complete the main and lateral directional wells for water injection into the sandstone reservoir using gravel packed 5 ½-in. and 3 ½-in. lateral bores. A milled window system level 5 junction and a 5 ½-in. upper tubing string were planned. A subsea tree will be installed and the well tied to the Barracuda floating production unit in the future.

The junction was installed successfully and the well temporarily abandoned as a future injector. Prior to abandonment the main and lateral wells were evaluated and the injectivity index achieved the reservoir requirements.

The second Barracuda multilateral injection well was drilled for the same purpose as the first well. The well features were identical except for the junction, which was Petrobras' first experience with a pre-milled window system.

While the junction was successful, this second well failed due to a number of reasons. Evaluation of the main bore was considered satisfactory but the lateral bore was much lower than the expectation due to a very high skin factor. An acidizing job was performed but the injectivity increment was still unsatisfactory. It was decided to flow the well to improve the injectivity index, however, the lateral bore frac-pac failed and sand from the gravel pack and formation were produced, requiring sand cleaning using a coiled tubing unit. Hard luck continued as the coiled tubing broke and the fishing operation became too complex to economically complete. The well was abandoned.

LESSONS LEARNED

Numerous lessons were learned for future multilateral applications as a result of the Bonito, Voador and Barracuda wells.

- Different approaches to remove debris were tested and the solutions utilized still require some evolution to reach the optimal point of risk reduction.
- The washover/mill-through operation has been performed with satisfactory results but some improvements to reduce rig time is necessary
- Junction completion was performed successfully but proper space-out of the tools at the junction is very important.
- Many interfaces surrounding the multilateral well require the right people with the right knowledge in the right place to avoid drastic consequences.
- Careful attention should be given to workover operations that require running coiled tubing or wireline after installation of the multilateral completion.

Petrobras says that multilateral technology still requires improvement but the fact that the Voador completion is still injecting since February 1999 and saved \$10 million by not drilling a second horizontal well shows that it is possible to take advantage of the present stage of the technology.

On the other hand, the experience with the workover of the Barracuda well shows the importance of risk assessment and the need for multilateral equipment that is friendlier to workover operations.

Meantime, Petrobras is planning a level 6 multilateral well on a 9 5/8-in. casing in an onshore well in preparation for a level 6 application offshore.

REFERENCE

This article is based upon a paper presented at the 2001 SPE/IADC Drilling Conference by **Gabriel Sotomayor, Ronaldo Oliveira** and **Ivan Alves** with Petrobras 