Openhole Cladding System Provides Effective, Economical and Reliable Zonal Isolation

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Abstract

A key challenge when drilling wells where reservoirs are very close together is the effective isolation of particular zones so that flow rate measurement and management are as precise as possible. Isolation methods to achieve this objective have historically included plugback cementation or using packers with swellable elastomers. By incorporating solid expandable tubular technology in the guise of an openhole cladding system, an operator in Nigeria took a different approach to appraise and test a potential reservoir using a well whose prime objective is to produce gas. In the case of this well, the drilling team was adamant on getting the results right the first time as these would guide future hydrocarbon exploration in the field.

The operator chose the cladding approach because other options held the potential hazard of impairing and damaging the target reservoir, thus jeopardizing its production potential. One option, plugback cementation, could reduce impairment and optimize data acquisition, but the resulting sidetrack and smaller hole size reduced the production potential. Packers with swellable elastomers are generally easy and simple to use, but over time, the ability of the rubbers to maintain sealing integrity is uncertain.

Installing the openhole cladding system enabled the operator to abandon and isolate the sand to be tested from the objective gas reservoir. The successful application of the openhole clad ensured the integrity of the production and acquisition of accurate data and readings and saved the operator over $3,000,000 on sidetrack operations.
This paper outlines the implementation process to apply solid expandable technology in this production/appraisal well. In addition, this paper explains how the openhole clad opens the door for effective use of solid expandable tubular technology in future wells in the area.

### Well Objectives

The primary objective of this well called for it to be a gas producer from the S3.0 sand. This gas-bearing reservoir most likely runs throughout the entire length of the reservoir. A secondary objective for this land well included appraising the S4.0 sand to determine the reservoir fluid type. The S4.0 could be gas bearing or water bearing as was the case on wells drilled down the flank, but no water samples were taken. The operator wanted to appraise this lower reservoir first and then isolate it from the upper reservoir, the S3.0 sand, without damaging the production potential of the latter. The ~10 feet of less-than-competent shale that separate the two sands added to the challenge of the isolation objective.

The drilling plan called for total depth (TD) of the well to be ~13,500 ft measured depth (MD) and 12,344 ft true vertical depth (TVD). The 13-3/8 in. surface casing was run to ~7,500 ft MD. A 9-5/8 in. production casing was installed to ~13,300 ft MD, just above the S3.0 sand. From the shoe of the 9-5/8 in. production casing, an 8-1/2 in. hole was planned to ~13,500 ft MD. This hole would traverse the S3.0 and S4.0 reservoirs and would be drilled using Thixsal mud, an over-saturated saltwater-based mud for high temperatures that help stabilize fluid and high water-loss properties. The operator defined as many of the project variables as possible including the expected downhole temperature of the S4.0 reservoir at ~250° F bottomhole static temperature. The maximum well inclination throughout the S3.0 and S4.0 sands would be 28.5°.

### Solution Options

The first option to be analyzed used a cement plug to isolate the S4.0 sand from the S3.0 (Figure 1). However, the potential for this approach to jeopardize the productivity of the S3.0 reservoir was judged extremely high and this solution was abandoned. Due to the nature of the shale, if a cement plug was used for isolation, the cement could seep into the S3.0 sand and reduce the porosity and permeability of the production zone, thus diminishing the capacity to produce this zone to its maximum potential. The second option considered consisted of plugging and abandoning the first hole drilled to evaluate the S4.0 sand and then sidetracking to drill a new hole to produce the S3.0 reservoir (Figure 2). The main drawback for the sidetrack lay in the operation cost and time consumption. A third option considered came from the experience and successful result of sister-company Petroleum Development Oman (PDO) who had isolated water-baring fractures from production zones in horizontal wells with solid expandable tubulars coupled with swellable elastomers.1&2

Solid expandable tubular technology provided an attractive solution because it had successfully been applied in the Middle East field to isolate water influx through fractures in carbonate horizontal wellbores and has enabled some of these wells to be water-free for over four years. The openhole cladding system consists of an expandable string run and installed to isolate an unstable formation, isolate salt water flow and shut off water influx in an openhole completion. The installation process for this system is similar to that of an expandable openhole liner with the exception that it is not tied back into the base casing. The elastomers are configured to seal against the formation. The formation properties, such as porosity, permeability and rock hardness, dictate the type of elastomers used that determine seal efficiency.3
Based on PDO’s successful results, the operator decided an openhole cladding system could be installed in the 8.500-inch hole using a 7.625 in. solid expandable tubular casing to expand to an outer diameter (OD) of up to 8.609 in. Throughout the entire length of each joint of expandable tubular, elastomer bands were installed that were designed to swell in Thixsal mud and salt-saturated brine (Figure 3). The system consisted of 250 ft of solid expandable tubular joints, a launcher with a bull plug instead of a conventional float shoe and the required expansion tools.

The Solid Expandable Solution

System Design

The system design considered the usual wellbore variables, such as temperature, inclination and formation characteristics. But as is typical with drilling operations, each wellbore plan must take into account the potential and probable repercussions of drilling in those particular conditions, circumstances and environment. For this project the swellable elastomers needed to be suitable for saturated brines. The ideal length of the cladding system needed to be accurately defined and placed as to properly seal the S4 sand without jeopardizing the producing ability of the S3 sand. These issues were addressed in the design phase, which also included a significant logistical challenge. The equipment first traveled from Houston to The Netherlands for elastomer installation before being delivered to Nigeria. Samples of Thixsal mud and brines were sent to Holland to test and choose the best type of swellable elastomers. The expandable cladding system was sent to Holland for the elastomer installation and then to Nigeria. In spite of the circuitous route the equipment took, the process still managed to be completed in a very expedient timeframe.

System Installation

With the plan in place and the equipment delivered, the operator drilled to the planned TD and tested and evaluated the S4.0 sand. After all logs had been run, operations commenced for installing the expandable cladding system. The launcher and six joints of expandable casing were made up and run into the hole. Once the last joint was made up and hung with slips from the rotary table, a false table was placed above it. The false table allowed the solid expandable system to be hung on the rotary table while running the drillpipe inner string until its is screwed into the expansion assembly at the bottom of the expandable string (Figure 4 & 5). When the drillpipe reached the launcher and engaged the expansion cone, the slips were lifted from the rotary table and the cladding system was run to TD. The openhole cladding system was designed to be long enough to cover the entire S4.0 sand and the shale sections below and above it. The cladding system was placed in position and the expansion process started. Hydraulic pressure supplied by the cement pumping units initiated expansion at 4,100 psi. After expansion, the clad was tested for positioning and leakage.
Expansion Results

The installation of this expandable system isolated the S4.0 reservoir, a first on a sandstone formation. The operator successfully isolated the S4.0 reservoir after appraising it without jeopardizing the ability to optimize gas production from the S3.0 reservoir. The operator estimated a savings of $3MM in plug-back and sidetrack operations by using the openhole cladding system instead of cement plugs and straddle packer isolation.

System Highlights

The expandable openhole cladding system provides a cost-effective solution for a myriad of wellbore conditions and challenges. Because of how the system is designed, anchor hanger joints at each end of the liner create sizing options. Anchor hanger joints incorporate elastomer bands bonded to the OD of the expandable liner, and the diameter of the borehole dictates the thickness of the elastomers. Additional anchor hangers can be placed anywhere along the length of the liner to create an openhole seal. The expandable cladding system covers problematic zones that result in substantial savings realized from not sealing the entire open hole.

To illustrate the versatility of this technology, another operator in the Middle East used the system in a customized application when drilling a 1,000m (3,280 ft) horizontal section through a highly-fractured carbonate formation in a completed well. Water from the aquifer flowed through the fractures and reduced the oil cut to 10%. This operator installed a 5-1/2 x 6-1/8 in. expandable system that clads across the fracture conduit, sealing the water-producing fractures and permanently eliminating water invasion. The outcome of this installation doubled the oil cut and provided sufficient room to run full-size logging and stimulation tools in the resulting internal diameter.

Conclusion

One of the challenges of realizing the full potential presented by solid expandable tubular technology is in recognizing how diverse it actually is. This technology is applicable to casing repair and enhancement, offers both cased-hole and openhole zonal isolation, and controls loss zones, over-pressured zones and mechanical instability during drilling. By comparing and contrasting possible solutions for zonal isolation, the operator was able to delineate the features, advantages and benefits of each option as pertaining to their requirements, conditions and situation. The economics of using an expandable cladding system provided the most attractive means by which to achieve the drilling objectives defined. The robust nature of the system and the expeditious manner in which the equipment was delivered and installed, coupled with the actual economic savings, verified that the technology delivered a cost-effective and technically-sound solution.

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References


Figure 1 – Cement plug option for isolating lower sand zone.

Figure 2 – Sidetracking option for isolating lower sand zone.
Figure 3 – Openhole clad design for normal joints (36% elastomer coverage).

Figure 4 – Running a solid expandable tubular system prior to installing false rotary table.
Figure 5 – Running drillpipe through a false rotary table into the solid expandable tubular system.