Isolation Barrier Valves Installed Successfully in Deepwater Gulf of Guinea

A major operator manages multiple deepwater projects in the Gulf of Guinea. This paper describes one of these, a recent 44-well project. The operator required an ISO 28781-qualified bidirectional subsurface isolation barrier valve (IBV) to be installed in each well. This paper presents the results of the IBV deployment in the field.

Fig. 1—Subsurface IBV design for the offshore Egina field.

Introduction

The Egina field was discovered in 2003 in Oil Mining Lease 130 located in deep water (1150–1750 m) approximately 200 km offshore Port Harcourt, Nigeria.

Subsurface IBVs have become commonplace in lower-sandface-completion installations. The potential time and operational cost savings are well understood. However, industry concerns remain regarding the ability of these devices to operate reliably in demanding wellbore conditions.

The primary challenges for this project were

- Deviated wells with horizontal drains, high dogleg severity, and azimuth changes
- Isolation of different reservoirs along each drain
- Faults
- Running the upper completion in sieved nonaqueous-based mud (NABM)

Well-Control Philosophy and Barrier Requirements

General philosophies and requirements for well control—including the overall principles for well barriers, kill methods, and project-specific needs—require the following with respect to barriers:

- Can be pressure-tested
- Location and status can be known at all times
- Can be re-established in a short period of time
- Can operate in the environment despite challenges related to pressures, temperatures, and fluids

The integrity of a barrier can be verified by pressure-testing to working pressure in the direction of flow when possible. These tests can also be run in the reverse direction. After completion and tree installation, tests are conducted using available well pressure.

IBV Design Update. The IBV design in question (**Fig. 1**) was first run in west Africa in 2008 as a result of an extensive qualification and testing program aimed at improving upon its predecessor. The new IBV improved debris tolerance to meet ISO 28781 regulatory requirements. Enhancements also included increased differential opening pressure, simplified operating and workshop-testing procedures, removal of the transit pin, and increased opening force.

This valve technology provides an interventionless solution for fluid-loss control that eliminates potential formation damage, reduces overall costs on subsea wells significantly, and provides a reliable barrier in the well-suspension system. Also, no well-specific setup is necessary in the event of changes in setting depth or downhole temperature. The debris-tolerant, nontranslating ball system is designed to hold pressure from above and below to enable full surface- and downhole-equipment-integrity testing. The valve-cycling mechanism is isolated from wellbore fluid and debris and the actuation system is unaffected by changes in hydrostatic pressure, thus enhancing long-term suspension reliability. A collet-shifting tool is attached to the end of the washpipe, which, on retrieval, closes the valve, immediately isolating the reservoir. Remote actuation in the form of hydraulic-pressure cycles from the rig or host vessel is then used to open the valve after upper completion installation.

Operational Preparation. All operations are prepared using standard job travelers for each of the completion bottomhole assemblies (BHAs).

The reliability and operational success of the IBV is dependent on the wellbore conditions in which it is deployed. The experience gained from multiple global installations of these IBVs has shown that successful operations are linked strongly to the cleanliness of the wellbore above the valve.

Procedures

The IBV is run in the open position as an integral part of the lower completion. A collet-shifting tool closes the ball, isolating the formation and allowing inflow and positive pressure testing. The reservoirs are isolated by the closed ball in

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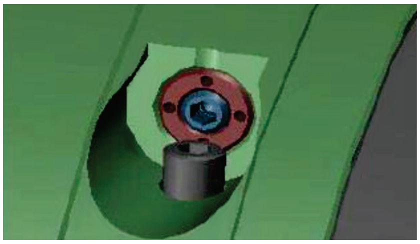

Fig. 2—Equalizing-stem indexing mode.

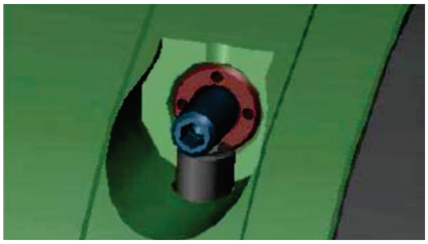

Fig. 3—Equalizing-stem test position.

the IBV, allowing safe installation of the upper completion from a floating rig or well suspension without a subsea tree. The use of an ISO 28781-rated qualified IBV provides both zonal isolation and fluid-loss control. Once a well is completed and subsea tree installed, the IBV is opened remotely by applying multiple tubing pressure cycles.

Work Flow: Running in Hole (RIH) With the IBV.

1. Before picking up the IBV, the ball must be in the open position and the equalizing stem must be in the indexing mode. The indexing mode is confirmed when the end face of the stem (around the hex socket) is flush with the equalizing-stem retainer (**Figs. 2 and 3**).
2. Pick up and make up the IBV.
3. Continue running lower completion equipment and washpipe per relevant procedures.
4. Set and test the sandface packer.
5. Perform the sandface operation as necessary.

Work flows for closing and pressure- and inflow-testing the IBV are provided in the complete paper, as are procedures for displacing the well to unfiltered/uninhibited and filtered/inhibited brine.

IBV Opening Procedure. Following upper-completion and subsea-tree installation, the remote operation of the IBV is achieved by cycling and bleeding down the applied tubing pressure to activate the indexing mechanism incorporated within the liquid spring section. This, in turn, triggers the opening of the IBV without the need for well intervention. The complete paper outlines the nature and number of pressure cycles necessary to remotely open the IBV. The maximum tubing pressure that can be applied to the IBV is determined by the working pressure of the valve.

Cycling of the liquid spring section occurs as pressure is bled off. Instant indication of the ball opening may be evident on the final cycle, depending on reservoir pressure. If the downhole pressure gauge is incorporated into the completion design, a change in downhole pressure should be evident upon remote opening. A further positive indication will occur during further attempts to apply pressure above the ball, resulting in the inability to exceed formation pressure.

Results

The IBVs have been installed in both horizontal openhole-gravel-pack and standalone-screen applications for barrier provision. The IBV discussed has been used in oil- and water-based drilling fluids, filtered brines, and seawater-based fluids. Installations have been performed in depths up to 1600 m, and deviations from 56 to 90° have been encountered. Most of the wells featured IBVs installed at deviations between 75 and 90°.

The first batch of wells was drilled and completed with lower completions and suspended while waiting for subsea-tree deliveries. Later, the wells were drilled and completed with both lower and upper completions with trees installed from a vessel. The IBVs were closed and inflow- and pressure-tested during the lower-completion phase.

All IBVs were run in sieved NABM. Filtered high-viscosity pills were spotted across the IBV before closing. Once closed, the casing above the IBV was displaced to filtered completion brine at a rate ensuring that any debris was lifted to surface. The IBVs remained suspended until the operator performed flowback and injectivity testing from a drillship. Additional injectivity tests were performed from a vessel. Well-suspension duration with the IBVs closed varied between 2 months and 2.5 years. All valves cycled opened without issues. Four coiled-tubing interventions were performed following successful remote openings in the field with no difficulties reported, confirming that IBVs were in fully open positions.

Lessons Learned

- All subassemblies including the IBV assembly are sent to rig with 6⅝-in. handling subs.
- Supervisors should pay close attention to blank pipe, screens, and washpipe cleanliness.
- The depth at which overpull is observed when closing the IBV must be recorded and compared with the IBV shifting-profile depth in the pull-out-of-hole washpipe tally. This can help confirm packer depth for spaceout.
- Cleanliness of brine after displacing NABM from well is not a concern.
- The fluid supervisor must ensure that brine and cleaning pills are mixed offline, not online.
- Even given the multitude of debris testing conducted, and successful valve openings, the importance of wellbore cleanliness should not be underemphasized before and during IBV installation.
- In the first batch of wells, a dedicated wellbore cleanout run was performed after well re-entry. Later, wells were drilled and completed with both lower and upper completions. In these wells, this run was not executed and well cleaning was limited to circulations with lower-completion service tools and washpipe. Despite removing this dedicated cleanout run, no negative effect on IBV remote opening and functionality was observed in any wells.

Conclusions

The IBV has been successfully installed in 24 wells at the time of writing. Average pressure- and inflow-test duration, including displacing NABM and pumping and reversing base oil over the course of 24 wells, is 6 hours. To date, 20 valves have been remotely opened with zero nonproductive time. The average well-suspension duration was over 300 days, with the longest measured at 917 days. **JPT**