Teamwork, Collaboration Deliver Technological Success for Complex Deepwater TLP Project

The Total Moho Nord offshore development and production project in the Republic of the Congo presents multiple technological and logistical challenges requiring customized solutions, strong collaboration between operator and service provider and a broad array of technical expertise and equipment. The development, when completed, will include 45 deepwater wells, 17 of which are designed with dry trees on a tension leg platform (TLP). Twelve of the TLP wells are oil producers with gas lift systems and the other five are water injectors to manage pressure.

The CT intervention tower, which included the first-time integration of a remotely operated CIRP completion insertion and removal under pressure system, is designed to insert and retrieve long gun strings under wellhead pressure. (Courtesy of Schlumberger)

For these wells, drilling operations using a mast equipment package (MEP) and various types of coiled tubing (CT) intervention, including perforating, must be run simultaneously. The TLP project began in June 2015 with an extensive design and planning phase addressing space, deck loading, weight and other parameters. The successful installation of the initial dry Christmas tree well two years later achieved several industry ‘firsts’ in technological innovations and applications. The project highlights the importance of ongoing teamwork between Total and Schlumberger.

The undertaking also reflects the commitment of Schlumberger to advance its expertise and technology by building capacity, developing infrastructure, and recruiting and training employees where it operates. With 80% of the Schlumberger local workforce involved in this project, the company seeks to develop a strong national employment base in Congo. To achieve this, Schlumberger has created a vigorous training program in Congo for each business function.

To assist development of the Moho Nord project, Total and Schlumberger launched the ‘Train the Trainer Program’ in 2015. Through the Schlumberger recruiting department, experienced industry professionals were invited to share operational knowledge with selected universities of the Republic of Congo. Thirteen days of training, totaling 90 hours, were conducted for 33 university professors on Schlumberger technology and best practices.

"Thank you for the training, it was excellent. I received very good feedback from the teachers who were invited, and all of them want to make this a common practice as it is really refreshing. We will debrief together and see how we can improve our lessons," said the Dean of Marien Ngouabi University.

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Coiled Tubing Compensated Intervention Tower

The centerpiece of the first TLP dry Christmas tree is a custom-engineered CT intervention tower configured with a heave motion-compensating system. Designed specifically to fit on the limited-space deck of the TLP, the tower can skid easily from one well slot to another and convey a long string of perforating guns even while working below the MEP. For this first-ever global deployment, the CT tower was engineered to operate independently from the drilling activity and at its maximum-extension working height both underneath and alongside of the MEP. By enabling safer and simultaneous drilling and intervention operations, the tower delivered considerable time, cost, and risk reductions.

Advanced Fluids and Technology for Well Construction

The MHA1-01 well, an oil producer with gas lift, was drilled in 2016 in water depth of 780 m (2,559 ft) in the Albian age multilayer carbonate reservoir, which is characterized by high vertical heterogeneity. Continual communication between Total and M-I SWACO, a Schlumberger company, ensured selection of the optimal drilling fluid technologies and waste management services for both performance and efficiency. For example, the rig-based ENVIROUNIT* offshore slop water treatment system recycled the slop water to significantly reduce disposal costs over its 14-month deployment.

The M-I SWACO Wellbore Productivity team also saved two days of rig time by combining three operations—cleaning the internal diameter (ID) of the polished bore receptacle (PBR) to confirm top of liner depth, inflow testing the 4½-in liner and cleaning the wellbore—in a single run. The specially designed tieback mill used to drift and clean the PBR's ID was developed by M-I SWACO after performing multiple torque-and-drag and simulations from the VIRTUAL COMPLETION SOLUTIONS* completion fluid modeling software package to demonstrate operational feasibility.

Dual Completions with a 20-Year Well Life Expectancy

The first dual completion was installed on the Moho Nord TLP in March 2017. For this initial well, Total and Schlumberger Completions engaged early on to design a fit-for-purpose technology, incorporating multiple system integration tests (SITs) to achieve a 20-year well life expectancy.

The design addresses the TLP requirements and weight distribution of the completion and the challenging well architecture, with a 10¾-in × 7⅝-in casing scheme. Other issues include constraints associated with pressure and temperature variations due to production and injection cycles and corrosive produced fluid.

Key technologies introduced in the completion design include a tubing-fill test valve (TFTV) to enable filling and testing the tubing while running in the hole, a dual XMP premium multiport production packer installed below the mudline, a 7⅝-in XHP premium production packer, a tubing-mounted chemical injection mandrel, and a DCIN-II dual-check chemical injection nipple.

The completion hardware was also designed to accommodate other key components including subsurface safety valves and real-time monitoring with downhole pressure and temperature gauges.

Simultaneous Drilling, Intervention

On March 31, 2017, the intervention team positioned the CT intervention tower on MHA1-01 as the rig skidded to the next slot to begin drilling the second well. Simultaneously with the drilling operation, the team performed a cement bond logging run using Schlumberger ACTive* real-time

downhole coiled tubing services, which use real-time downhole measurements to interpret and optimize treatments while they are in progress.

Early in the project, Total had determined that customized engineering would be required to accommodate intervention operations on the TLP and achieve the key objective of perforating with up to 150 m (492 ft) of guns on CT conveyance to depth in a single run. Following perforating operations, the guns would need to be pulled out of hole in a live well condition without killing the well.

The solution to this challenge was a custom-built motion-compensated CT intervention tower, featuring the first-time integration of a remotely operated CIRP* completion insertion and removal under pressure system, which inserts and retrieves long gun strings under wellhead pressure. In addition to the customized tower dimensions, a 5/16-in braided wireline cable for gun deployment was integrated with the tower while an A-frame/gin pole crane facilitated gun deployment in the live well to meet the working height limitations below the MEP. A custom CT well control stackup that worked within the tower's dimensional limits was rigged up on top of the Christmas tree, as enabled by the motion-compensation system.

The initial SIT and factory acceptance test (FAT) of the CIRP system stack and CT intervention tower in Lafayette, Louisiana, validated tower functionality. A second SIT was performed in November 2016 at the Schlumberger base in Pointe-Noire, Republic of the Congo, to simulate the deployment under pressure functionality with the CIRP system and the braided wire using wireline pressure control equipment (PCE).

In February 2017, a final commissioning SIT was performed of all the components rigged up for the first time together on the TLP, including a full CIRP system gun deployment simulation and interference test with the MEP conducted simultaneously with MHA1-01 drilling operations. The offshore SIT validated the functionality and technical interfaces across the CT tower, CIRP system equipment, and braided wireline cable, and ultimately improved operational procedures by allowing application of lessons learned on the first well execution.

Engineers from multiple Schlumberger product lines are involved in the Moho Nord exploration and production project, providing opportunities for collaboration and sharing of lessons learned and best practices. (Courtesy of Schlumberger)

Single-Run Long Perforation in Deep Water

For the first well intervention operation, 81.8 m (269 ft) of perforating guns and spacers was deployed in hole on the braided line using the CIRP system and bowl/slips. The job marked the world's first CIRP system perforation operation on a TLP in deep water. The perforating guns were conveyed to depth using ACTive Perf* CT real-time perforating services in combination with ACTive GR* CT real-time gamma ray logging tool and casing collar locator for depth correlation.

The guns were activated on the first attempt using the eFire-TCP* tubing-conveyed perforating electronic firing head, as verified by ACTive services' downhole data acquisition. The CIRP system enabled perforation of 78 m (256 ft) of reservoir section in a single run and post-perforation retrieval with braided wire under live well conditions.

After an initial acid wash of the perforations was performed on the bottom 15 m (49 ft) of the reservoir interval, the well was handed over to the Schlumberger Testing & Process team for well cleanup and well testing. A memory production logging tool (MPLT) conveyed on slickline was deployed through the CT intervention tower at various stages of the well flowback operation. After conducting a larger acid stimulation operation, the team performed a second well test cleanup and MPLT run. All operations were executed simultaneously with the TLP drilling operation, with no HSE incidents.

Collaboration and the application of advanced technology and workflows for all phases, from planning and design through drilling, completion, single-run perforation and well testing, were instrumental in not only delivering the first Moho Nord TLP well in May 2017 but also ensuring long-term success of the Moho Nord campaign.

*Mark of Schlumberger or a Schlumberger company

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