Beating the learning curve in extended reach wells

THE ABU DHABI COMPANY FOR ONSHORE OIL OPERATIONS (ADCO) has a program of exploration and appraisal drilling from artificial islands in an environmentally sensitive shallow marine location. In early 2000, ADCO management set up a team to look at the feasibility of drilling extended-reach wells to reduce both the impact on the environment and the cost of drilling these wells.

ADCO is drilling an extended-reach well with a measured depth of 18,748 ft and a horizontal displacement of 13,780 ft.

When ADCO started to prepare for this well the company and the newly formed drilling team had limited experience of extended-reach drilling (ERD). However, progress on the well has been extraordinary. When the pilot hole reached target depth the well was 39 days ahead of the program. This drilling performance is in the upper quartile of global land-based ERD wells (defined by industry analysts as better than 24.6 days per 10,000 feet drilled).

The appraisal-drilling program has included the construction of man-made islands to give access to offshore parts of the field. In this context, the need for ERD was identified for this field. By minimizing the footprint of drilling operations in such a pristine environment, ERD offered a way of controlling the impact of drilling activity. It also has considerable cost impact by reducing the number of islands to be built.

However, global experience indicates that non-conventional wells, including extended-reach wells, typically require a higher allowance for nonproductive time. Incomplete knowledge, unscheduled events and equipment limitations can add 30% or more to the overall time taken to deliver the well.

PLANNING AND PROCESSES

It is widely accepted that ERD is more risky than conventional drilling. However, the record of ERD projects around the world, and in particular that of BP Amoco at Wytch Farm in the UK, demonstrates that as experience is gained, well-delivery performance improves.

In the absence of practical ERD experience, ADCO's challenge in drilling its first extended-reach well was to minimize risks – to beat the learning curve. The starting point was to determine the feasibility of the proposed well prior to committing to the project.

PRE-PROJECT FEASIBILITY STUDY

In early 2000, ADCO set up a study team to determine the feasibility and requirements of drilling an extended-reach well from an artificial island in an environmentally sensitive area. The study addressed rig sizing, tool and equipment specifications and personnel experience. The team's approach was to identify the key risks (potential problems) to well delivery, and the tools and practices needed to manage them. A wide range of risks was examined, including the effects of torque and drag, the ability to clean cuttings from the hole efficiently, and the consequences of stuck pipe.

ESTABLISHING THE TEAM

The feasibility study recognized the lack of appropriate experience within ADCO. Acquiring and applying ERD knowledge was therefore critical to the success of the well and ADCO sought access to the global experience of its partners and the service industry.

Directional drilling and mud companies were evaluated not only on their performance but also on their ability to bring experienced personnel to the operation. The emphasis on harnessing the expertise of individuals for the benefit of the project was maintained throughout the planning and execution of the well. For example, an ERD specialist from the directional drilling contractor was co-located with the ADCO drilling team. Additionally, world-class modeling and simulation expertise was made available through one of the partners.

In 1998, the directional drilling contractor had in place a network structure to provide the best possible quality and delivery of service within ERD projects. Using this network, knowledge transfer between ERD engineers working around the world was formalized. A database was set up to capture case histories, technological solutions and techniques, best practices, and other related ERD topics. Technical experts validated all database content before making it available through an intranet website.

The directional drilling engineer was able to use this network to apply ERD lessons from around the world to the ADCO well. In addition, the technical and engineering capabilities of the directional drilling company's engineering product centers were available, as was its network of ERD specialists working in a variety of capacities around the world. Communication in all cases was facilitated by the directional drilling company's world-class, high-bandwidth intranet infrastructure. Optimal solutions resulted from teaming up with ADCO personnel in order to make available the directional drilling contractor's corporate knowledge.

In addition to service company expertise, ADCO secured the participation of a consultant from the BP Research Center in Sunbury, UK, to overcome limited local understanding of modeling and simulation in ERD wells. The consultant undertook coaching and training of the local team to build its knowledge and to ensure that the various alternative models were used effectively.

The team also planned to apply certain aspects of ADCO's well delivery limit (WDL) methodology to the drilling the ERD well. This approach, developed by ADCO and based on "technical limit drilling", resulted in significant savings in drilling time since being introduced.

The complete WDL approach involves in-depth analysis of all aspects of well construction prior to starting the well in order to determine the best well construction performance that can be achieved for a given design. The approach strives to minimize operational time compared with offset wells, and is particularly applicable to complex, high-cost projects such as ERD. By involving participants in challenging the well program, the WDL approach also maximizes the opportunity for participants to set their own stretch targets and take credit for the success of the well.

After substantially completing the well planning, the ERD team planned to involve the whole team and use collaborative aspects of WDL to transfer a solid working knowledge of the program to the rig site, and to agree to challenging delivery times.

RIG SELECTION

The team selecting the rig focused on prediction of torque and drag, and-hole cleaning hydraulics, then used these to specify the rig capacity. The drilling contractor was the National Drilling Company (NDC), with two rigs available with sufficient drawworks capacity and mud-pump output to drill the proposed well.

Of the two rigs available, Rig ND24 had already established a reputation for performance and was one of the first rigs to implement the WDL approach. The team was confident that the rig's relatively new equipment, proven track record for efficiency and reliability, and experience in implementing WDL methods would result in the 20% performance improvement needed to justify the significant cost premium for the rig.

Modeling showed that the maximum standpipe pressure available would limit the flow rate at section total depth to 950 gal/min, requiring vigilance, attention to good hole cleaning, and, if necessary moderation, of ROP. In addition, the predicted high torque levels needed to drill the 8 1 /2-in. section required a top drive that was not included as part of the rig equipment.

Accepting these limitations, Rig ND24 was selected for the ERD well and plans were made to rent and install a top drive for the duration of the well.

WELL PROGRAM

Over a period of three months, the drilling team built up a detailed drilling program covering the basic equipment requirements, identified global best practices and completed detailed modeling for each phase. The program prepared by ADCO and the directional drilling contractor's project manager paid particular attention to the nature of the formations to be drilled. The well profile chosen was a combination of a constant rate and an incremental variable-rate build.

A number of factors were considered when making a choice between water- or oil-based drilling fluids for each hole section. Inhibition of swelling clays (Albian shale), mud weight in order to balance formation pressure (upper Cretaceous), the resultant fluid rheologies, logistics, environmental and economics were all considered when concluding the drilling program. During the planning stage, technical discussions took place between ADCO's Petroleum Development Department and the drilling team on the best way to drill the reservoir. The preferred horizontal hole size and the type of mud to be used were high on the agenda.

WELL DELIVERY RESULTS

Without compromising health, safety and environmental (HSE) standards, the promise of improved drilling efficiency through WDL methodology has been dramatically realized in completing the ERD pilot hole.

Drilling performance on the ERD well has been spectacular. The 7-in pilot hole target depth was reached in 43.5 days, 39 days ahead of the program. Moreover, at all stages of drilling the pilot hole, the well was ahead of the best-of-best depth/time curve defined during target setting in the ERD workshop.

The best-of-best benchmark was computed by adding together the best performance ever achieved by ADCO in the each section of wells in the same field. At section target depth the well was four days (10%) ahead of the best of best for the less challenging wells drilled to date in the field. Nonproductive time was 2.5%, mainly due to an MWD tool failure in the 17 ½-in. hole. The chosen well trajectory anticipated the potential drilling problems and resulted in a smooth tangent section, with directional targets met.

The planning process and WDL methodology were the foundations for the team's achievements and unprecedented drilling performance. For example, when losses were encountered in the Paleocene formations, a contingency plan had already been considered before spudding the well, and no time was lost in making a decision to use seawater to drill ahead with total losses.

The problem was addressed with confidence and drilling resumed without falling behind the curve. No further losses were encountered, with PWD data ensuring good control of ECD at all time. Drilling efficiency was also attributed to the hole-cleaning performance. PWD measurements validated the hydraulics model, and enabled hole cleaning to be optimized.

Torque-and-drag predictions were similarly validated There were no unexpected drillpipe stresses, no evidence of casing wear due to drillpipe side forces (confirmed by the absence of significant metal in the mud returns) and casing was successfully run.

During drilling the real-time downhole weight on bit (DWOB) and torque on bit (DTOR) measurements were valuable for assessing the transfer of weight to the bit and bit performance. The rotating friction factor and drag logs computed from DWOB and DTOR enabled the validity of the models to be checked and allowance made for any discrepancies.

ADCO has achieved outstanding performance while drilling and completing the pilot hole of its first ERD well. Sound processes, thorough planning and adequate preparation were the keys to defining a program that addressed the anticipated risks.

Modeling of torque, drag and hydraulics was invaluable in determining the feasibility of drilling alternative well trajectories, in sizing equipment and in planning operations. When the program was mature, validation by peer review confirmed that it was comprehensive and realistic.

The WDL workshop helped each individual understand his role in the well delivery and by involving them in the process, made sure of their commitment to a successful outcome. It also resulted in the setting of aggressive targets that were agreed by the whole team.

REFERENCE

This article was adapted from an IADC/SPE paper "World-Class Extedned Reach Drilling Performance in Abu Dhabi — A Case Study in How to Beat the Learning Curve," by **Abdullah Saeed AlSuwaidi** and **Rady Ahmed El-Nashar** with **Abu Dhabi Company for Onshore Oil Operations (ADCO)**; **Frank Allen**, ADCO; and **Fernando J Brandao**, **Schlumberger Drilling & Measurement**.