Through tubing drilling on N Cormorant cuts costs

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THROUGH TUBING ROTARY drilling (TTRD) is a technique whereby short step out sidetracks may be performed by drilling a slim (typically 4⅛-in.) hole through the existing completion tubulars.

Using this method the Christmas tree and completion tubulars are not required to be removed for the drilling operation. A whipstock is set and a window is milled in the existing liner.

Then 2⅞-in. jointed drill pipe is used to drill the well through the completion tubing to a new location. A slim 2⅞-in. liner may then be run and cemented in place before the well is conventionally perforated.

Following **Shell Expro**'s first TTRD well in the Brent field (BB-08) in early 1998, 2 further TTRD wells (CN-18S5 and CN-29S3) were successfully drilled on the North Cormorant platform during 2000.

CTD AND TTRD

Within Shell's Northern Business Unit, TTRD has emerged as a complimentary technique to the more mature coiled tubing drilling (CTD) methodology. Since 1996, Shell Expro's NBU has used CTD on 6 applications to achieve short step out sidetracks.

CTD has the principle advantage of not requiring a drill derrick to execute the technique and operations may be performed concurrently with main rig activities depending on slot availability. Significant learning about CTD has taken place with its benefits and limitations now well understood.

Differential sticking with CTD was identified early on as one of the principal risks associated with the method. This has been proven in practice to be the case on some wells.

Freeing techniques such as reducing the hydrostatic have been less successful than predicted, leading in some cases to hole collapse.

With the constraints of the limited overpull capacity of coil tubing and an inability to rotate the string, the inherent risks of the methodology are significant and must be factored into the economics. Also, a large concurrent window of around 60 days must be identified to realize a CTD well opportunity.

Another consideration is cost. The cost of a typical CTD well has been difficult to achieve for less than £2.5 million.

With rig operating rates declining, conventional wells and TTRD wells using the drill derrick have never been more cost effective and may be commonly drilled for less than this.

By comparison, the two TTRD wells drilled last year on the North Cormorant platform were successfully drilled for £1.5 million and £1.0 million.

DESIGN CONSIDERATIONS

Although TTRD is perceived as a rig-based activity, with the correct sequence planning significant work may be performed concurrently on the skid deck.

On CN-29S3 for instance, the existing wellbore was abandoned with wireline plugs and the whipstock set offline using **Schlumberger** electric line.

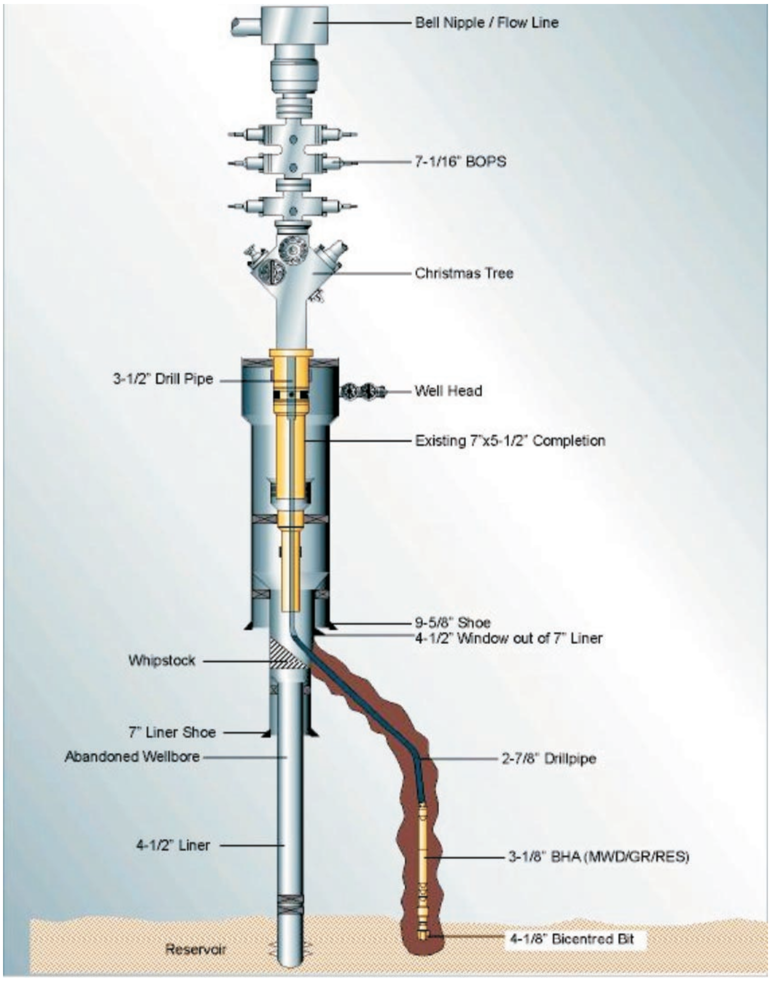

Figure 1: Through tubing rotary drilling schematic includes slim hole 7¹⁄₁₆-in. BOP on top of the Christmas tree. Wear flange is installed at the base of the BOP to protect tree.

The main rig was then skidded over to perform the window milling, drilling and liner running phases.

Following a drift run to confirm wireline access the rig was again skidded away to other operations with the well successfully perforated offline using 1.56-in. guns.

Offline opportunities here ensured that the drilling rig was required for only 18.5 days in total.

TTRD requires slim hole 7¹⁄₁₆-in. BOPs to be installed on top of the Christmas tree (Figure 1).

Again, as much rig up and testing as possible is performed offline.

A 5⅜-in. wear flange is installed at the base of the BOPs to avoid wear on the Christmas tree and valve profiles. Tubing wear with this type of drilling, however, has been generally modeled to be a non-critical design consideration.

This has been supported by magnet recovery data and caliper log information from other operators.

The primary drill string for drilling through the 5½-in. production tubing is 2⅞-in. drill pipe. A short section of up to 2,000 ft of 3½-in. pipe is utilized at the top of the string where 7-in. tubing is positioned.

The 2⅞-in. Hydril WT-23 drill pipe was used successfully on CN-18S5 and exhibits good drilling properties in terms of joint strength and adequate hydraulics.

The internal upsets however make it non-receptive to wiper darts and so a separate tubing string had to be picked up for the running of the 2⅞-in. liner.

This operation was successful, but required 3 days to pick up and lay down the liner running string.

For the next TTRD well, CN-29s3, the Hydril 533 thread was researched in some detail. Although essentially a tubing thread, this tubular type has a drilling track record and has a plug friendly internal profile with little upset.

A string was subsequently sourced and used to both drill the well and run the liner on CN-29S3.

Handling and racking of slim tubulars is a relatively unfamiliar process for rig crews and carries some inherent safety risks.

In this respect an intermediate racking board was commissioned and installed to facilitate the safe handling and racking of slim tubulars.

Deviation work in this hole size carries operational risks largely due to the limited data available for different motor, bit, formation and deviation applications, particularly with bi-center bits.

Getting behind on turn also means that very quickly large doglegs are required to catch up on the directional plan.

On CN-18S5 for instance, achieving the required 10 deg/100 ft dogleg was not achieved initially with the bi-center bit and motor combination selected. So 15 deg/100 ft or more was soon required to achieve the required target.

A more powerful motor delivering 50% more torque plus an increased bend setting was picked up. These assembly changes permitted more effective directional control and the well was aggressively steered to successfully hit the target.

The flexibility of the drilling assembly is clearly demonstrated in Figure 2 and further underlines the significant challenge involved in achieving the required directional objectives.

TECHNIQUES COMPARED

When considering the relative merits of CTD versus TTRD, two observed examples highlight some important differences.

On CN-18S5, the drill string became stuck briefly while making a connection. To free the pipe eventually required 30,000 lb overpull.

Figure 2: 3⅛-in. flexible drilling assembly includes, beginning with top arrow, Mach XL motor (BHI), Slimpulse MWD (Anadrill, resistivity tool (TARGET), filter sub (BHI) and thruster (BHI).

This amount of pull would likely not have been possible with CTD and so the assembly would have been irrevocably stuck if using this technique.

Also, cuttings weighing apparatus was put in place for both TTRD wells.

On CN-18S5, some 70% of the theoretical cuttings were measurably recovered. Later, during steering work on CN-29S3, the difference in cuttings returns between sliding and rotating modes was clearly seen to fluctuate between 0 and 100% on some occasions.

In spite of its merits, CTD cannot achieve the same level of hole cleaning efficiency as TTRD.

Even with good cuttings returns, the absolute volume of cuttings for 2,500 ft of 4⅛-in. hole amounts to only a handful of skips.

Cuttings disposal via skip and ship therefore becomes a viable alternative to cuttings re-injection when using this method, and was subsequently implemented on CN-29S3.

Non-conventional equipment on this

type of operation gives rise to a number of potential pitfalls.

Organizing a dedicated BHA session to physically screw the BHAs together on the beach has proven to pay dividends in terms of recognizing handling issues and confirming cross-over compatibilities up front.

This session can be conveniently organized with the small size tubulars in question (see Figure 2).

One additional advantage of small tubulars with makeup torques of around 1,500 ft-lb is that BHAs may be partially made up offline on the deck using hydraulic mini tongs.

Drilling fluid used on both sidetracks was BHI Carbosea low-toxic oil-based mud. At achievable pump rates of around 120 gpm, a low rheology mud system was modeled and specified for use.

Low shear rate rheology was then carefully monitored during drilling using the RJF viscometer to ensure that low end rheology did not enter the barite sag zone.

The 4-in. mud pump liners were specially ordered for the sections and a pill pit was modified for use as the active pit to reduce circulating volumes.

One different aspect of drilling through tubing is that some common well control considerations may vary.

A slim hole being drilled beneath the completion packer may be regarded as an extended perforation tunnel. The completion tubing is, of course, designed for complete evacuation to hydrocarbons and so the normal kick tolerance parameter becomes less significant from a point of view of allowable well pressures.

That said, the entire open hole volume may comprise only 10-20 bbl while drilling and so a large loss of hydrostatic with proportionate closed in surface pressures may be quickly induced.

On CN-29S3, a swabbed kick while tripping out was successfully closed in after 3 bbl and effectively dealt with.

Problems, however, with stripping to bottom under well pressure and pumping out of hole complicated the well kill operation.

Detailed lessons here have been carefully documented for the next TTRD well.

A relatively conventional liner cementation procedure was followed on both wells with a 2⅞-in. liner. And 3.6-in. OD Spirolisers were installed at 2 per joint to optimize cementation quality and hold the non-upset pipe off the borehole wall for differential sticking prevention while running.

No rotation was specified primarily due to risk of twist off. A 16-ppg slurry was batched and pumped in conventional fashion and displaced with mud.

A coiled tubing clean out of the slim liner on CN-18S5 was programmed in order to prepare the liner for perforation.

Planned top of cement on the CN-29S3 was around 500 ft below top of liner. This offered the advantage of no cement falling into the liner top after the cementation.

A wireline drift run and perforations were subsequently performed without the need for a dedicated coiled tubing clean out run.

RESULTS AND CONCLUSION

Through tubing rotary drilling is a cost effective technique for achieving short step out sidetracks. The two wells drilled last year had costs as low as £1 million—a first for Shell Expro.

Other significant firsts include the UK sector's longest TTRD well at 2,500 ft and the first 4½-in. window exit from a 7-in. liner to be performed.

Authors' Note:

KCA is lead drilling contractor to Shell Expro's Northern Business Unit (NBU) and manages drilling operations for all nine NBU platform rigs (Brent A, B, C, D, Cormorant Alpha, North Cormorant, Tern, Eider and Dunlin). Shell UK Exploration and Production (known as Shell Expro) is operator in the UK sector of the North Sea for Shell, Exxon Mobil and other co-venturers. ■