This case history showcases NeoTork's utilization in a well (N05-01x) that was side-tracked from an existing well (N05-01) following a discovery, to better ascertain the size of the geological structure. After about 1,000 meters (m) drilled, N05-01x had to be abandoned because of a pressure incident forcing the operator to cement the whole BHA downhole. A third well was then drilled (N05-01xx), this time without NeoTork. Those three very similar wells, one drilled using NeoTork and the two others without, allow a clear comparison of the impact of NeoTork on drilling performance.

Application Description

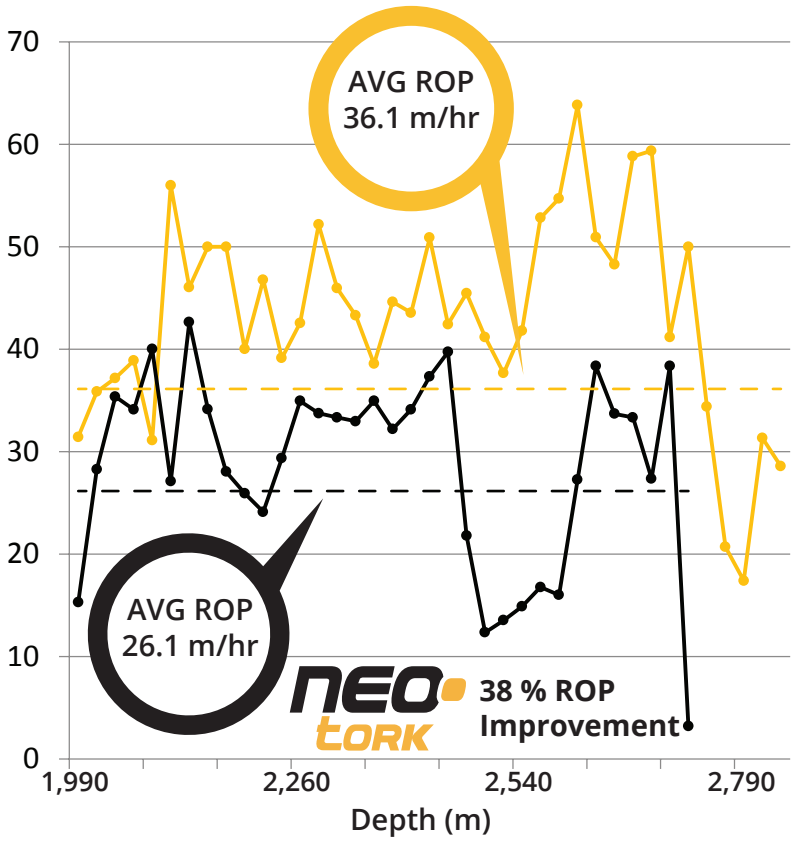
N05-01 was targeting a specific geologic structure in the Top Findorf sand. The well was drilled using a RSS powered by a PDM and the bit was a TK66 from NOV (IADC M222). At a depth of 2744m the 8 ½ section was completed and the well extended by a 6" drain. That drain hit a hydrocarbon bearing zone and tests identified good potential. To better define the size of the pay, a side-track well, kicking off from N05-01 9" 5/8 casing was decided.

N05-01x was drilled using a RSS system. NeoTork was located at approximately 40m from the bit which was a PDC type TD506X from Baker Hughes (IADC M223). After 962m drilled and at the depth of 2832m, an inflow was observed. While trying to control the well, a crack occurred in the upper formation and the well started to lose mud from that level, while still producing water from the bottom. After a few attempts to solve this issue, it was decided to cement the whole BHA downhole and abandon that well for a second side-track.

N05-01xx was side-tracked from 1860m depth. The side-track assembly drilled down to 2150m where a new RSS assembly, powering a PDC bit TD506X from Baker Hughes (IADC M223), was run. This new assembly completed the 8 ½ section.

The lithology drilled on those three wells was identical however N05-01x was not vertical but had a small deviation, from 6° to 18° with a total TVD difference of 19m. N05-01xx had a hole angle ranging from 5° to 10°. The drilled rocks consisted mostly of salt, clay and at the bottom of the section a hard level of anhydrite and carbonate, which will be one of the focus of this case study. All three wells were drilled consecutively using the same contractors, and both N05-01x and N05-01xx used the same drill bit.

ROP Difference N05-01 vs. N05-01x



Despite the fact that N05-01x was a side-track and was kicked off with controlled parameters it delivered a much better ROP than that achieved drilling N05-01. The daily progress report on the left clearly highlights the difference in progression between both wells.

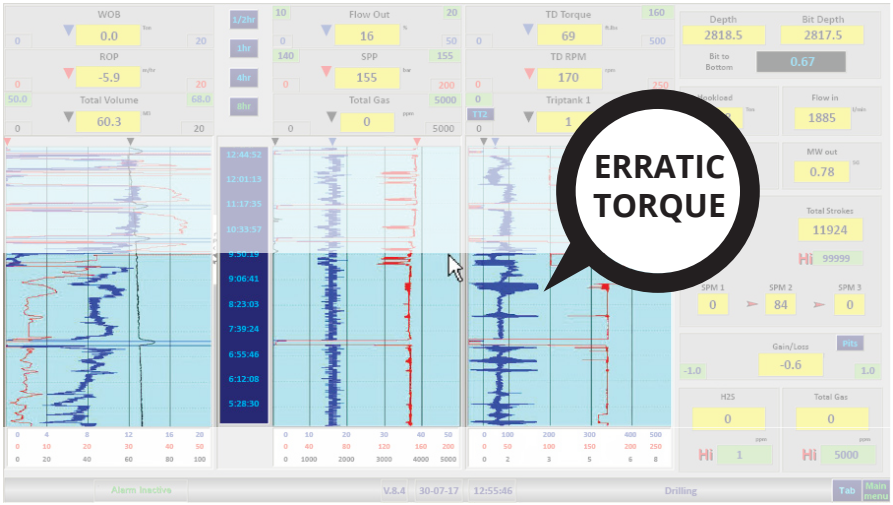
The improvement in performance was made possible as, due to NeoTork downhole action, superior drilling parameters could be set when drilling N05-01x as surface sensors showed a steady torque and downhole measurements were exhibiting shock level 0 and stick-slip 3 to 10%,.

The overall improvement in ROP when comparing both wells was approximately 40%, however ROP was improved threefold at specific points during drilling (see chart).

Comparative Analysis N05-01x and N05-01xx

Bit Wear

After the side-track was completed, the third well - N05-01xx - was drilled with an identical BHA and drill bit than N05-01x. A run of 543m was completed in 37.72 hrs (average ROP 14.4 m/hr). However, NO5-01x did not benefit as much from the easier salt and clay drilling conditions at the top of the section. In order to present the most unbiased comparison, this case study will focus on the bottom part of both runs where they crossed the Zechstein Group/Z2, predominantly composed of anhydrites and carbonates that are a notorious cause of lower ROP (as they tend to increase downhole vibrations and stick-slip).



The chart on the left is a screenshot of the driller monitoring panel whilst crossing that interval on N05-01xx. A WOB of 10 tons and RPM of 170 delivered a 5 to 7m/hr ROP but with highly erratic surface torque. Both the erratic torque, but also the need to control parameters to reduce stick-slip, are mentioned throughout the drilling report related to this interval.

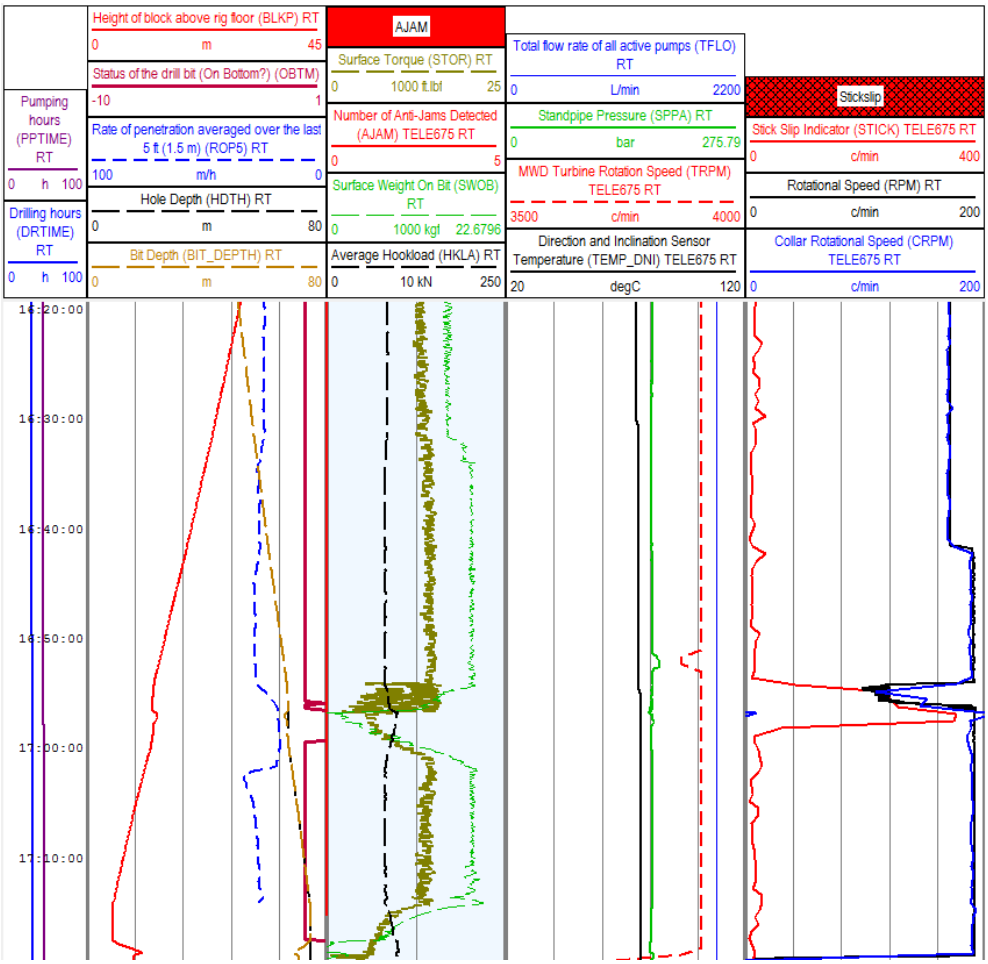
The chart on the right represents the same interval when drilled using NeoTork on N05-01x. Due to the steadiness in the surface and downhole sensors, parameters could be optimised and WOB was pushed to 18 tons while RPM were increased to 200. As a result this section was drilled with an average ROP of 28 to 36m/hr; a fivefold improvement on what was achieved when drilling the same interval using same bit / assembly on N05-01xx.

ROP

Below are the results of drill-off tests done whilst drilling N05-01x upper anhydrite layer. These illustrate further NeoTork's ability to work at higher parameters.

Depth Interval	WOB (T)	RPM	Torque (kFt.Lbs)	ROP (m/hr)	Slip & Stick	Shocks Level
2767m - 2776m	15	170	11 - 12	26	3-10% ratio	0
2776m - 2780m	18	170	12 - 13	29	3-10% ratio	0
2780m - 2785m	18	190	12 - 13	31	3-10% ratio	0
2785m - 2785.5m	18	120	8 - 15	20	3-10% ratio	1
2785.5m - 2795m	18	190	8 - 15	29	3-10% ratio	0

The tests show that NeoTork proved highly efficient under enhanced drilling parameters: stick-slip remained almost negligible and vibrations were at level 0 (see chart below). It is worth noting that a drastic drop in RPM had an immediate detrimental effect on stick-slip, as would be expected. Both RPM and WOB need to be balanced to secure smooth drilling conditions.

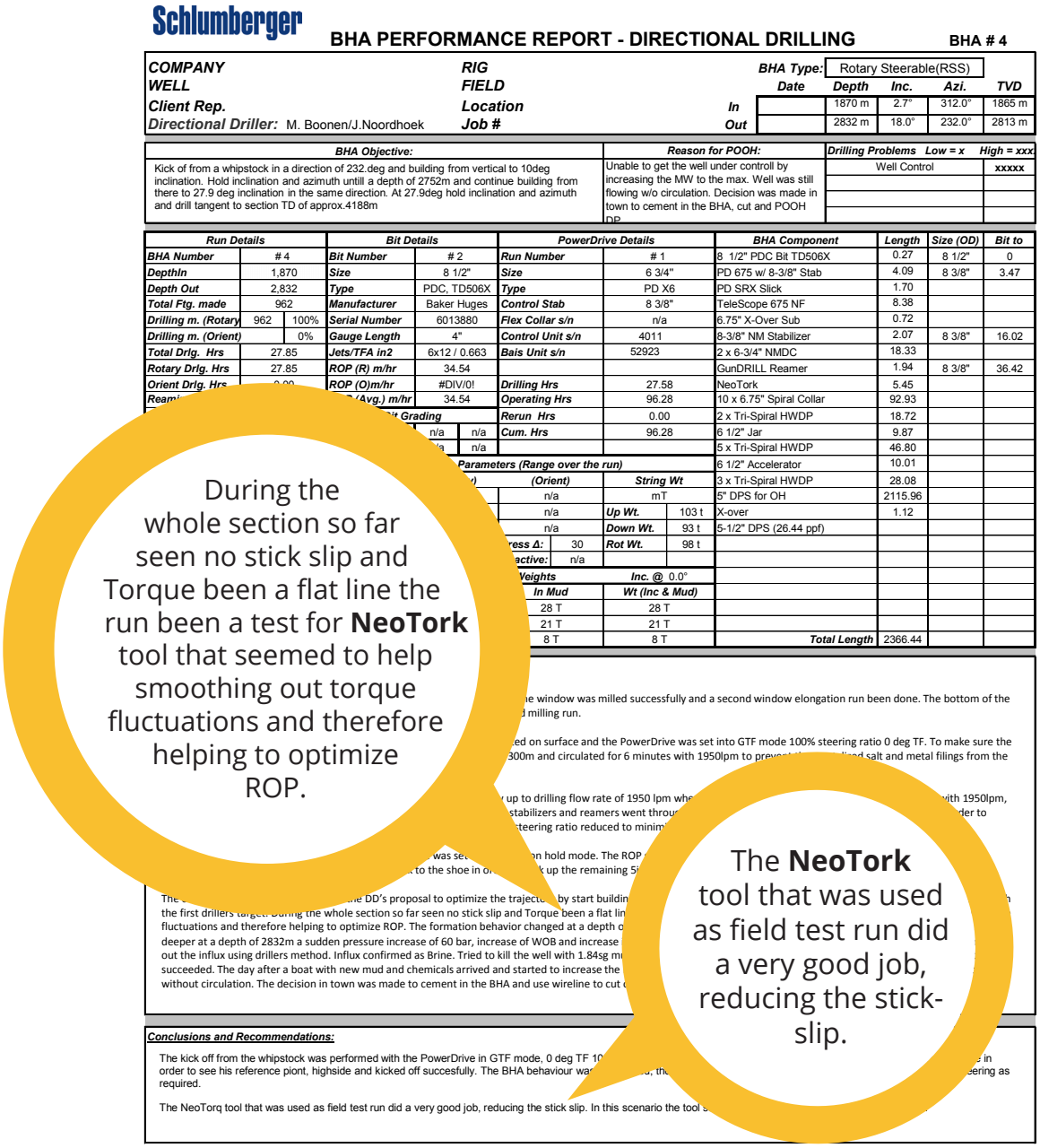


Summary and Conclusion

While this analysis is incomplete, as for obvious reasons bit wear could not be compared, it can be seen that the performance delivered by the NeoTork BHA on the N05-01x well was a marked improvement on the results achieved with similar or equal bits/BHA on the two reference wells.

As all other conditions were equal, this improvement in performance can be entirely attributed to NeoTork and its ability to allow optimised drilling parameters. This was particularly evident when drilling tougher formations (anhydrite) where an 80% increase in WOB and 20% on RPM resulted in ROP multiplying up to fivefold through the same interval.

Statistics aside, the strongest argument for utilizing a new technology remains the positive feedback from third party users. Below, is an extract from the directional drilling contractor's report, highlighting the obvious benefits of using NeoTork.



Schlumberger

BHA PERFORMANCE REPORT - DIRECTIONAL DRILLING — BHA # 4

COMPANY		RIG		BHA Type:	Rotary Steerable(RSS)			
WELL		FIELD			Date	Depth	Inc.	Azi.	TVD
Client Rep.		Location		In		1870 m	2.7°	312.0°	1865 m
Directional Driller:	M. Boonen/J.Noordhoek	Job #		Out		2832 m	18.0°	232.0°	2813 m

BHA Objective:	Reason for POOH:	Drilling Problems Low = x	High = xxx
Kick of from a whipstock in a direction of 232.deg and building from vertical to 10deg inclination. Hold inclination and azimuth untill a depth of 2752m and continue building from there to 27.9 deg inclination in the same direction. At 27.9deg hold inclination and azimuth and drill tangent to section TD of approx.4188m	Unable to get the well under controll by increasing the MW to the max. Well was still flowing w/o circulation. Decision was made in town to cement in the BHA, cut and POOH DP	Well Control	xxxxx

Run Details		Bit Details		PowerDrive Details		BHA Component	Length	Size (OD)	Bit to
BHA Number	# 4	Bit Number	# 2	Run Number	# 1	8 1/2" PDC Bit TD506X	0.27	8 1/2"	0
DepthIn	1,870	Size	8 1/2"	Size	6 3/4"	PD 675 w/ 8-3/8" Stab	4.09	8 3/8"	3.47
Depth Out	2,832	Type	PDC, TD506X	Type	PD X6	PD SRX Slick	1.70		
Total Ftg. made	962	Manufacturer	Baker Huges	Control Stab	8 3/8"	TeleScope 675 NF	8.38		
Drilling m. (Rotary	962 100%	Serial Number	6013880	Flex Collar s/n	n/a	6.75" X-Over Sub	0.72		
Drilling m. (Orient)	0%	Gauge Length	4"	Control Unit s/n	4011	8-3/8" NM Stabilizer	2.07	8 3/8"	16.02
Total Drlg. Hrs	27.85	Jets/TFA in2	6x12 / 0.663	Bais Unit s/n	52923	2 x 6-3/4" NMDC	18.33		
Rotary Drlg. Hrs	27.85	ROP (R) m/hr	34.54			GunDRILL Reamer	1.94	8 3/8"	36.42
Orient Drlg. Hrs	0.00	ROP (O)m/hr	#DIV/0!	Drilling Hrs	27.58	NeoTork	5.45		
Ream		(Avg.) m/hr	34.54	Operating Hrs	96.28	10 x 6.75" Spiral Collar	92.93		
		it Grading		Rerun Hrs	0.00	2 x Tri-Spiral HWDP	18.72		
		n/a	n/a	Cum. Hrs	96.28	6 1/2" Jar	9.87		
		/a	n/a			5 x Tri-Spiral HWDP	46.80		
		Parameters (Range over the run)				6 1/2" Accelerator	10.01		
		(Orient)		String Wt		3 x Tri-Spiral HWDP	28.08		
		n/a		mT		5" DPS for OH	2115.96		
		n/a		Up Wt.	103 t	X-over	1.12		
		n/a		Down Wt.	93 t	5-1/2" DPS (26.44 ppf)			
		ress Δ:	30	Rot Wt.	98 t				
		active:	n/a						
		Weights		Inc. @ 0.0°					
		In Mud		Wt (Inc & Mud)					
		28 T		28 T					
		21 T		21 T					
		8 T		8 T		Total Length	2366.44		

During the whole section so far seen no stick slip and Torque been a flat line the run been a test for **NeoTork** tool that seemed to help smoothing out torque fluctuations and therefore helping to optimize ROP.

The **NeoTork** tool that was used as field test run did a very good job, reducing the stick-slip.

Conclusions and Recommendations:

The kick off from the whipstock was performed with the PowerDrive in GTF mode, 0 deg TF 10 ... in order to see his reference piont, highside and kicked off succesfully. The BHA behaviour wa ... th ... eering as required.

The NeoTorq tool that was used as field test run did a very good job, reducing the stick slip. In this scenario the tool s ...