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REACTIV™ SUB

Stabilized Accentuated
Drilling Assurance Technology

Introduction

Oil and gas drilling operations have always been challenging though the crew make it look routine. One of the earliest things we learn about drilling is that even where the wells are identical, drilling of any particular well should be based on its own merits. The implication is that irrespective of how similar two well designs may be, each well can provide entirely different challenges even when drilled in the same fault block and into the same reservoirs.

Drilling is an incredibly challenging, yet interesting discipline. The oil industry is arguably the only industry where everything is based on intuition and what we think we know because most times our knowledge of an event is made clearer over time. This makes managing sub-surface drilling risk at the very core of drilling engineers and crews do.

In the early 1990s a study conducted by BP indicated the company was losing over \$30 million/year to stuck pipe incidents and the industry as a whole was losing around \$250 million/year. The research shows that in 1989/90 the average cost of a stuckpipe incident per well was \$170 thousand. Taking into consideration that the average rig cost in the 1980s and 1990s are significantly lower than the costs today, the average loss per well is definitely well over \$1 million. In a recent well in South-East Asia, the total cost of pulling a string out of hole for a successful clean-up run was estimated at \$780 thousand while the cost of a possible sidetrack to redrill the drain-hole section was estimated at \$3.8 million. It is therefore safe to say the current industry average loss to stuck pipe incidents is well over \$1 billion and probably between \$1 billion and \$5 billion today.

As recent as 2020 Petronas published of stuck pipe incidents and the cost of associated NPTs (see Figure 1 below).

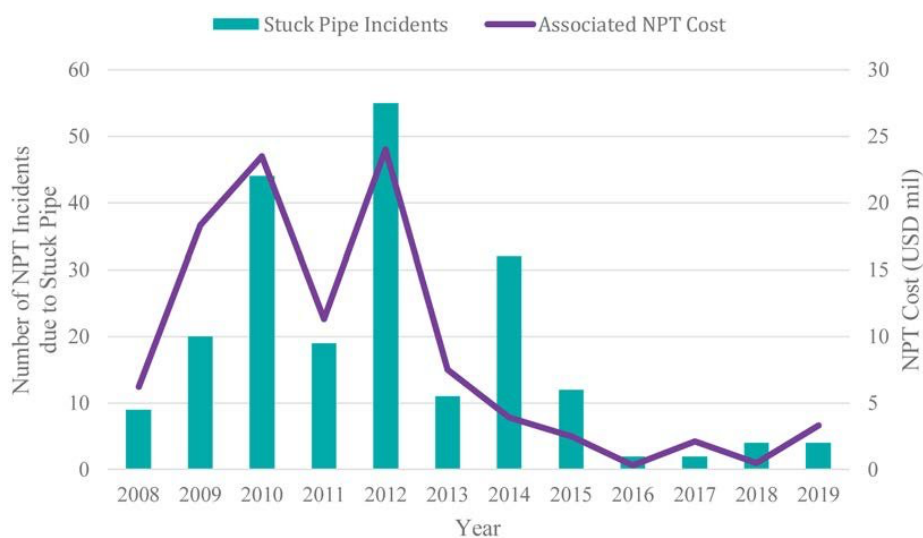


Figure 1: Stuck pipe events statistics for Petronas (Meor M. Hakeem Meor Hashim & Dalila Gomes, 2021)

In a separate study carried out by PDO and published in 2022 ([SPE Paper 211738](#)) they showed that a total of 1,568 days was lost due to stuck events between 2013 and 2017 equating to an average of \$15.5 million/year.

Stuck pipe events referred to relate to drilling and completion operations and therefore include BHAs, casing, liner and completions and costs associated with recovery. Stuck pipe events occur for several reasons ranging from poor drilling practices, poor drilling fluid chemistry/rheology to geological formations. The industry has allocated considerable resources to tackling drilling related stuck pipe events with training, real time monitoring of downhole and surface conditions and sometimes modifying and optimizing drill string designs. However, the industry response has been limited to current technology.



What is the REACTv Sub?

Drilling operations, engineering and risk mitigation or the well engineering discipline is driven by data and the accuracy of such data and its applicability to the current well or project may determine the outcome of the project. This is the basis for collating correlating well data to establish performance benchmarks, anticipated risks and proffer adequate mitigation for operational efficiency and to safeguard lives, property and the environment.

Table 1 lists 6 ERD gas wells drilled on land in the Arctic Circle which were completed as 6⁵/₈ or 4¹/₂ inch producers. The engineering concern was to have more power so for most parts drill pipe and top drive were all designed for high torque with the drilling contractors needing to buy brand new drill pipe to meet the required thresholds. Yet in some of these wells the triple-combo (with radioactive source) BHA could not be easily pulled out of hole due to excessive surface torque beyond the capacity of the 5¹/₂ inch drill pipe while drilling the 8¹/₂ inch hole. In Well 5 it took 9 days to successfully work the BHA past the shale overlying the reservoir after successfully completing the drilling operation and yet the clean-out BHA was ultimately lost in hole. Each time the BHA was pulled into the shales the torque increased significantly beyond the maximum allowable make up torque for the high torque connections.

Table 1: Summary of ERD wells drilled in a field in the Arctic Circle (2010 – 2012)

Well #	Type	MD (m)	TVD (m)	Step-out (m)	ERD Ratio
1	Multilateral	6390	2881.8	5711	1.98
		6051	2846.5	4374	1.54
2	single drain	6980	2886.3	5366	1.86
3	single drain	7274	2894.5	5834	2.02
4	Multilateral	7418	2904.0	6063	2.09
		7438	2879.8	6153	2.14
5	single drain	7819	2895.0	6489	2.24
6	single drain	8497	2906.2	7059	2.43

Figure 2 is a typical design for spiral string stabilizer showing the steep leading edge of the stabilizer blades. A watermelon design with a gradual or flushed leading edge would be more appropriate had torque been considered a possible challenge at the design phase.

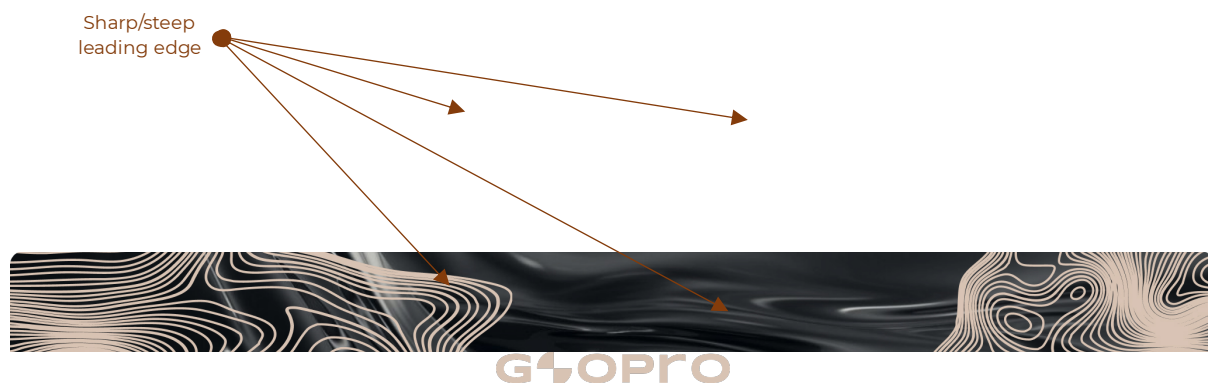




Figure 2: Typical spiral string stabilizer design

On the other hand, imagine what possibilities a fluid self-powered reamer that acts independently of the string would have provided in such an operation. There would have been a savings of 9 days and the well would have been completed, tied back to the surface production facilities within 14 days of completing the well. This would have resulted in a savings of \$4.22 million (2011) which is the loss to the general contractor for this singular event since the rig was still on standby for over 90 days, two tractor runs were needed to convey charges to sever the drill pipe from the rest of the BHA and both tractors were damaged beyond repair, and then the eventual re-drill of the section prior to completion.

The REACTv™ Sub is actually designed for such a case as described above. It is a concept that Geopro envisioned in 2016 as the MRS STAR (motorized reamer system with **ST**abilized **A**ccentuated **R**eamer housing).

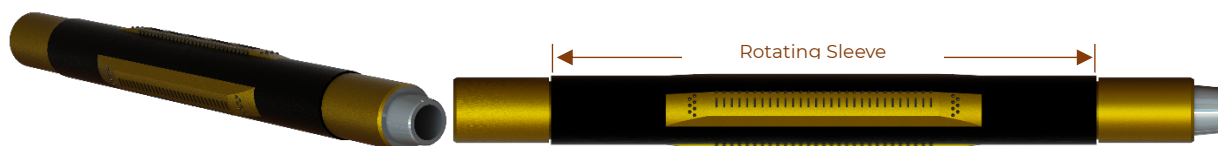


Figure 3: REACTv™ Sub 713 System

Description

The REACTv™ Sub is a drilling solution specifically designed to improve drilling efficiency. It is powered by a 2.0 – 3.5 stage 9:10 lobe mud motor power section. It is fluid activated but whereas in a typical mud motor the rotor is allowed to spin and the stator stationary with the drill string, for the REACTv™ Sub the reverse is the case as the rotor is connected to the rest of the drill string and the stator housing allowed to rotate/spin with fluid circulation through the tool. A 9:10 lobe configuration provides a more circular motion between the stator and rotor and provides an excitation level of 9 times per revolution.

The power section provides localized torque which is transmitted against the borehole by the bladed stabilized stator housing. This in provides 9 nutations per revolution and with 0.24 revolutions per gallon pumped for the 7¹/₈ inch collar based tool, this is equivalent to 144 rpms or 1296 nutations per minute with a circulation rate of 600 gpm.

The REACTv Sub actuates with circulation. When fluid is circulated up to the threshold flow rate, the external sleeve starts to rotate clockwise looking downwards. This rotation is irrespective of the rotation of the drill string. The sub is self torque-generating due to the drive mechanism that generates significant localised torque and subsequent rotation of the body of the tool.

This family of tools enable drilling teams to ream in and out of hole without string rotation making it the ultimate reaming solution for tight spots, hole pack-offs, swelling shales, and a host of wellbore instability related issues. Due to its unique internal power generation the REACTv™ Sub has a lower torque footprint within the drill string compared to regular drilling reamers and stabilisers. String rotation will increase available torque at the blades for more efficient rock deformation. Due to its unique harmonics it leads to reduced stick slip or destructive drill string vibrations.



The REACTv™ Sub provides drilling crews the ability to tackle downhole problems while improving drilling efficiency. The REACTv Sub is available for collar sizes from 4.75" to 11.25" and designed for use as an integral component of the drill string in all BHA configurations. Multiple REACTv Subs can be run in the same drill string.

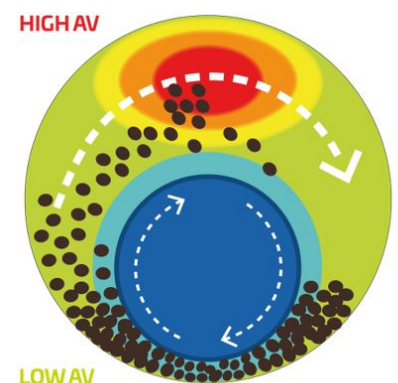
Summary of Features and Benefits

- Fluid actuated.
- Localized torque for independent reaming operation.
- Drilling optimization.
- Improves hole cleaning by stirring up cuttings/cuttings bed or loose formation into the fluid mid stream.
- Agitation function ensures better weight transfer to the bit/BHA. Unlike traditional agitators that work by creating a shock wave using a high speed mud motor power section, the REACTv™ Sub actively moves the string around the borehole wall circumference.
- Reduces frictional losses (torsional and axial) when drilling due rotation of the stabilized reamer independent of string rotation.
- Reduces / eliminates the need for unnecessary wiper trips or check trips, back reaming or reaming in general.
- Reduces / eliminates hole rugosity thus improving overall borehole quality and interpretation of formation evaluation data.
- Reduces/ eliminates stuck pipe occurrence and incidents and provides immediate, downhole remediation where it is needed.
- Delivers direct reaming capability at the tool offering drilling crews the ability to avert most geologically induced borehole drilling problems.
- Reduces drill string vibrations and significantly reduces the onset and impact of stick-slip on overall drilling performance.
- Reduces the need for multiple BHA components to achieve the same objective.
- Multiple tools can be deployed in the same drill string based on risk assessment and drilling objective.

Some Specific Benefits

Hole Cleaning

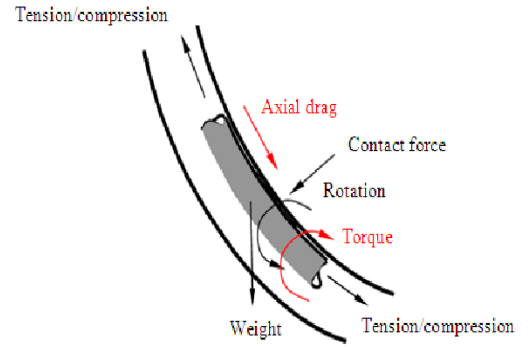
Hole cleaning in high angle and horizontal wells have been studied extensively. The results suggest there is an optimal circulating rate to pipe rotational speeds that enhance hole cleaning. Essentially it is commonly agreed that higher rotational speeds help with hole cleaning, especially with the removal of smaller cuttings, whereas increasing flow rate helps with larger sized cuttings. This does not negate the importance of fluid rheology. Typically, the effect of drill string rotation on hole cleaning depends on actual flow rates achievable, the dynamic behaviour of the drill string, cuttings size and mud rheology. The non-concentric motion of the drill string when rotated in the borehole in horizontal and highly deviated wells creates a whirl effect that agitates cuttings on the low side of the hole enabling improvements in hole cleaning by putting these cuttings in the higher velocity flow stream at the top of the hole. The REACTv™ Sub enhances hole cleaning by mechanically moving cuttings at the low side of the hole into the flow stream at higher RPMs than the drill string ever could, thus creating slightly higher annular velocities across the tool to improve hole cleaning.



Better Weight Transfer

The REACTV™ Sub comes standard with straight blades. This is because the tool is self-powered and will not necessarily require any additional torsional force to run in hole. Straight bladed profiles create less drag losses compared to spiral bladed profiles.

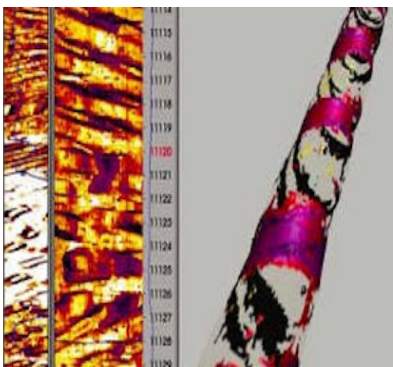
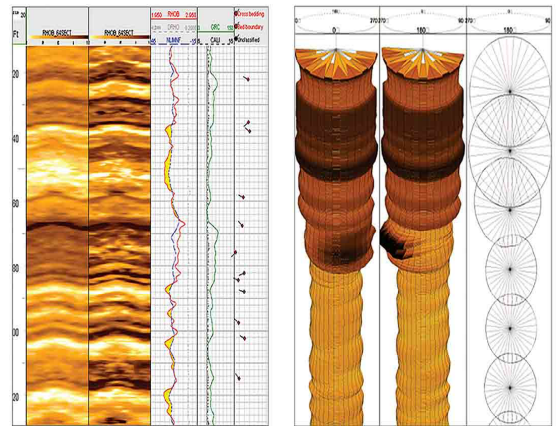
Furthermore, when the tool is activated, there is less or no drag losses from the tool when tripping with circulation and to an extent zero torque from the tool. This is because the external sleeve (stator) of the tool rotates with circulation while the rotor is physically coupled to the drill string. Due to the nutation of the stator when the tool is operational string forces are easily transmitted across the tool to the BHA with little restriction as the tool nutates 9 times with each revolution, resulting in:



- Better and smoother weight transfer to the BHA and consequently the drill bit
- Lower drill string torque since energy is much easily transmitted downhole
- Lower side forces compared to standard reamers and stabilizers
- Lower axial drag

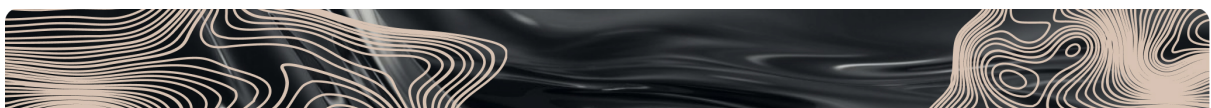
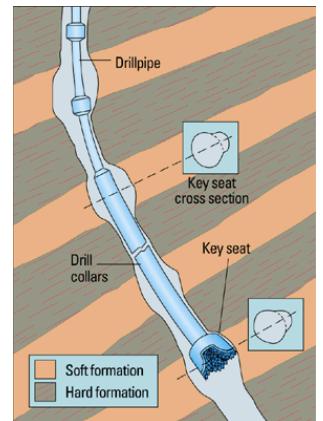
Borehole Quality

A major advantage of rotary steerable and rotary drilling compared to mud motor drilled holes, is the reduction in rugosity generally caused by the steering action of the BHA. This is more pronounced where there sliding and string rotation are carried out simultaneously to achieve the directional requirements. This is also present in holes drilled with rotary steerable systems though less pronounced. Hole rugosity makes accurate formation evaluation data interpretation more difficult and challenging.

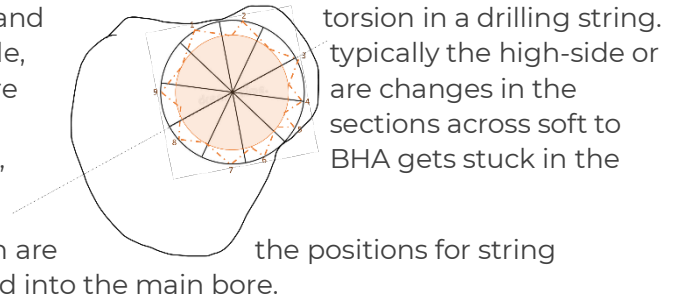


Micro tortuosity is created when borehole deviations occur on a scale smaller than the usual telemetry measurements are taken or recorded. These are undulations or changes in borehole direction and inclination that are not captured between survey stations. This results in apparent reduction in borehole hole diameter which in turn results in increase in frictional losses (drag and torque) and side-forces. Identifying the location of these apparent “reduced sections” in the wellbore can be useful in real-time decision making while drilling. The nutating

motion of the REACTV™ Sub is able to reduce micro-tortuosity by smoothing out the undulations with each revolution.



Key seating is caused when drilling with high tension and The drill string creates wear on a specific side of the hole, section with highest side forces, at wellbore where there direction. This tendency is more prevalent in wellbore medium hard formations. While pulling out of the hole, key



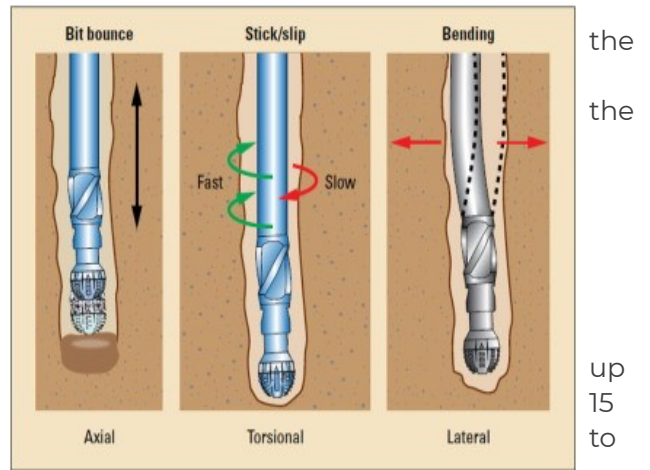
seat. The numbers shown on the key seat cross-section are nutation which guides the string out of the key seat and into the main bore.

Drill String Harmonics

shocks and vibrations present drilling challenges which could lead to inefficient drilling mechanics, damage to downhole tools, expensive fishing operations due to twist offs and stuck events.

Axial Vibrations

Bit bounce occurs due to insufficient weight on a bit to bite into a formation with a smooth drilling action but rather bounces off the bottom of the hole. It is the axial vibration of the drill string that typically occurs when drilling with tricone bits in hard rock formations. It leads to damage of bit cutting structure, bearings and seals, and results in flexing of the drill string causing even more damage from axial and lateral shocks. This is common with tricone bits. Axial motion created by bit bounce is dampened by nutation of the stator (stabilized housing) around the borehole. This action dissipates axial energy evenly to borehole walls and limits the axial travel of the drill string.



Torsional Vibrations

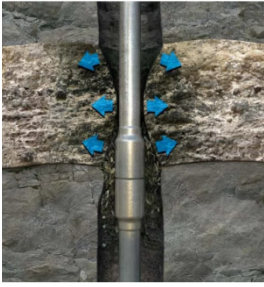
Stick-n-slip is irregular drill string rotation. This is caused by torsional motions as the bit stops rotating momentarily causing the string to periodically torque and then suddenly release the torsional build up at 2 to times the average surface rpm, causing severe damage the bit and BHA.

Lateral vibrations are very destructive. It includes **bit whirl** and **BHA whirl** (in extreme cases). Bit whirl occurs when the bit drilled hole diameter is much larger than the bit diameter causing the bit to wander around the wellbore instead of rotating smoothly about its natural centre. The over gauged hole in turn increases the tendency for the bit and BHA to continue whirling. BHA whirl is the eccentric rotation of the BHA around a point other than its geometric centre in a complex motion generating lateral displacements, shocks and increased friction against the wellbore. This may occur as forward or backward whirl and is the cause for BHA and down hole tool failure. Lateral shocks occur as lateral vibrations approach drill string resonance resulting in fluctuations of weight on bit and could include bit chatter.

The REACTV™ Sub allows the absorption or dissipation of energy that could be destructive and ensures it is not propagated through the drill string. It mitigates against uneven rotation by ensuring smoother weight transfer to the bit and ensures that torsional vibrations are low through uniform concentric nutation about the drilled hole.

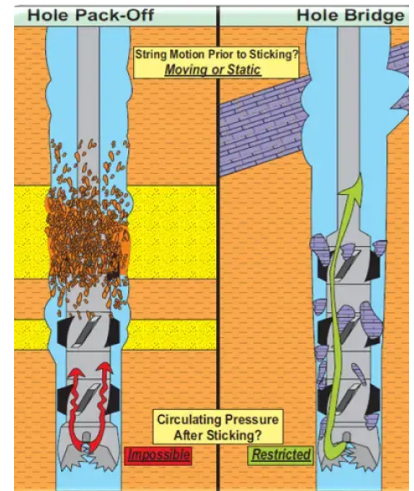
Stuck-pipe prevention



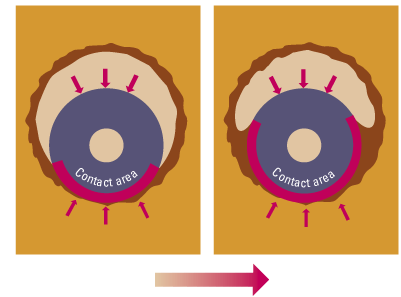


Drilling long sections through laminated, reactive or shaley formations can be quite challenging. Especially where the formations are prone to failure or swelling. In such situations the industry has traditionally used mud rheology and composition, forward and backward reaming, dedicated wiper trips and check trips at fixed intervals and fluid flow rates coupled with real time monitoring of both surface and downhole parameters and BHA

behaviour as mitigation. This approach has been relatively successful. In some instances, stuck-pipe events still occur due to hole restrictions or inability to pull through a tight spot due to extremely high string torque is inevitable. In such situations, the REACTv™ Sub acting as a trailing stabilizer at the top of the BHA separates/decouples drill string torque from the torque needed to ream through the obstacle by creating its own torque once the pumps are on. The torque generated by the tool and transmitted through the stabilizer blades, is capable of reaming through restrictions without the need for additional string torque.



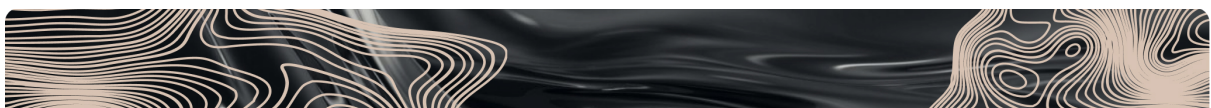
Differential sticking is caused by the differential pressure within the wellbore annulus and adjacent permeable formation resulting in a high contact force exerted over a sufficiently large area of the string. It is a condition where the drill string or casing string can neither be reciprocated nor rotated. Differential sticking is, for most drilling operations, the greatest problem worldwide in terms of time and financial cost. It is important to note that the sticking force is a product of the differential pressure between the wellbore and the reservoir and the area that the differential pressure is acting upon. This means that a relatively low differential pressure (Δp) applied over a large working area can be just as effective in sticking the pipe as can a high differential pressure applied over a small area (SLB, 2024).



Sizes & Specifications

Table 2: Tool Specifications & Performance Summary

Model Number	Tool \varnothing (in)	Hole \varnothing (in)	Blade \varnothing (in)	Stages	Lobes	Flow Range (GPM)	Revs (RPM)	Max. Diff ΔP (PSI)	Max. Torque (FT-LBS)
RCT 513_910_2.0	5 $\frac{1}{8}$	6 - 6 $\frac{1}{8}$	5 $\frac{5}{8}$	3.0	9:10	150 - 300	0.28	673	3616
RCT 713_910_2.0	7 $\frac{1}{8}$	8 $\frac{1}{2}$ - 8 $\frac{5}{8}$	8 $\frac{1}{8}$	2.0	9:10	300 - 600	0.24	410	3986
RCT 713_910_2.0_BC	7 $\frac{1}{8}$	8 $\frac{1}{2}$ - 9 $\frac{1}{2}$		2.0	9:10	300 - 600	0.24	410	3986
RCT 713_910_3.0	7 $\frac{1}{8}$	8 $\frac{1}{2}$ - 8 $\frac{5}{8}$	8 $\frac{1}{8}$	3.0	9:10	300 - 600	0.24	675	11377
RCT 713_910_3.0_BC	7 $\frac{1}{8}$	8 $\frac{1}{2}$ - 9 $\frac{1}{2}$	Integral Bicentric	3.0	9:10	300 - 600	0.24	675	11377
RCT 800_910_3.0	8	12 $\frac{1}{4}$	11 $\frac{3}{4}$	3.0	9:10	400 - 900	0.13	674	17227
RCT 800_910_3.0_BC	8	12 $\frac{1}{4}$ - 13 $\frac{1}{4}$	Integral Bicentric	3.0	9:10	400 - 900	0.13	674	17227



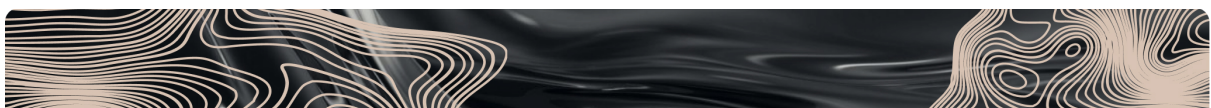
RCT 800_910_4.0	8	12¼	11¾	4.0	9:10	400 - 900	0.13	674	17227
RCT 800_910_4.0_BC	8	12¼ - 13¼	Integral Bicentric ¹	4.0	9:10	400 - 900	0.13	900	23003
RCT 950_910_3.0	9⅝	12¼	11¾	3.0	9:10	600 - 1200	0.124	1100	22529
RCT 950_910_3.0_BC	9⅝	12¼ - 13¼	Integral Bicentric ¹	3.0	9:10	600 - 1200	0.124	1100	22529
RCT 950_910_3.0	9⅝	12¼	11¾	4.0	9:10	600 - 1200	0.12	1475	31358
RCT 950_910_4.0_BC	9⅝	12¼ - 13¼	Integral Bicentric ¹	4.0	9:10	600 - 1200	0.12	1475	31358
RCT 950_910_4.0	9½	Up to 17½	Sleeve	4.0	9:10	600 - 1200	0.12	1475	31358



Summary

The REACTv™ Sub is a unique tool and yet based on technology the oilfield is accustomed to, positive displacement motors. The first attempt to have the stator tube spin in preference to the rotor was conceptualized and tested with our Motorised Reamer Shoe concept, the MRS in 2016 (Nkwocha, 2016). The REACTv™ Sub technology improves upon existing framework for drilling optimization and assurance by introducing active downhole technology that engages both the borehole and drill string in a specific manner to create improvements in hole cleaning, borehole quality, weight and torque transfer, smoother drilling performance, enhancing tool technology and ultimately, ensuring or mitigating against stuck pipe occurrence. Depending on the pump and stand-pipe pressure ratings, multiple tools can be run on the same drill string to tackle problems across several formations.

The REACTv™ Sub offers the drilling crew the ability to replace multiple downhole technologies such as the agitator, drilling reamer, stabilizer, shock sub, torque reduction subs and cuttings bed impellers with a single tool, thus reducing lost in hole exposure and BHA length. It is driven primarily by fluid circulation and self-powered, creating torque across the power section as fluid is circulated through it, reducing overall string torque demand, resulting in smoother transmissible torsional and axial energy to the BHA and bit and less problematic drilling events.

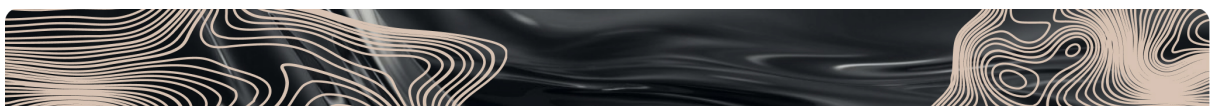


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