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Fit for Purpose Drilling Motor Design: A Case Study of Improved Drilling Efficiency in the 7-7/8” Hole Size

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Abstract

The recent success with drilling motors and their critical role in drilling applications is attributed to the focus on performance, reliability, and drilling efficiency. This paper highlights the development of a 6-1/2” drilling motor specifically designed for the 7-7/8” section. Traditionally, drilling motors for this 7-7/8” hole size were modified versions of those designed for the 8-1/2” section, resulting in suboptimal performance and reliability.

By focusing on usable power in terms of speed and torque generated, matched with the available differential pressure and flow, a new 6-1/2” even wall power section in the 0.27 rev/gal range was designed, generating approximately 33,000 lbf-ft at stall. The enhanced power output and torque generation capability of the power section enables the motor to efficiently drill through challenging formations. This, combined with a newly designed 6-1/2” bearing pack with improved load-bearing capacity and overall durability, enables the industry to push performance in the 7-7/8” lateral section with strong reliability.

This innovative motor configuration has proven highly effective in extended horizontal applications, with multiple runs exceeding 10,000 feet drilled. This 6-1/2” drilling motor has become a preferred choice for operators targeting lateral sections in the 7-7/8" hole size, enabling the entire section to be drilled using a single motor; thereby streamlining operations, reducing the number of trips, and improving overall efficiency.

The paper also discusses plans to develop a faster speed power section to improve drilling efficiency in the curve section enabling operators to combine sections such as the curve-lateral and further increase drilling efficiencies of extended-reach applications.

Introduction

Drilling of the 7-7/8" hole size in the Permian basin in the last couple of years as shown in Figure 1 has taken off, and rightfully so. This is a region which focuses on efficiency and productivity.

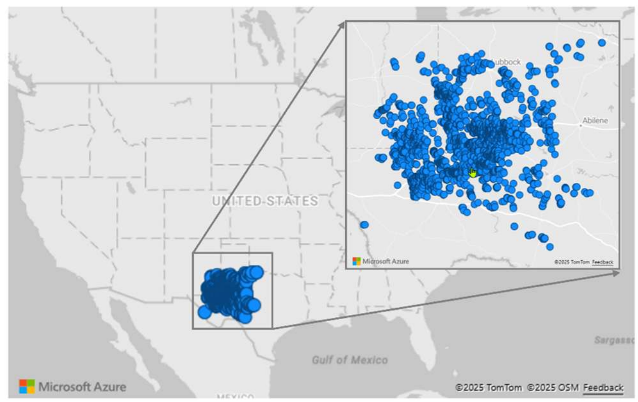

Figure 1 – Geolocation for wells drilled with 7-7/8” hole size in the Permian basin (Enverus, 2025)

From data as shown in Figure 2, 7-7/8” hole size drilled in the Permian Basin, the footage drilled was approx. 18.2M feet drilled in 2023 vs 8M feet drilled in 2017, that is 2.3 times in 2023 vs what was drilled in 2017. Focusing specifically on the lateral footage drilled, 1.7M was drilled in 2017 vs 9M in 2023, that is 5.3 times in 2023 vs what was drilled in 2017.

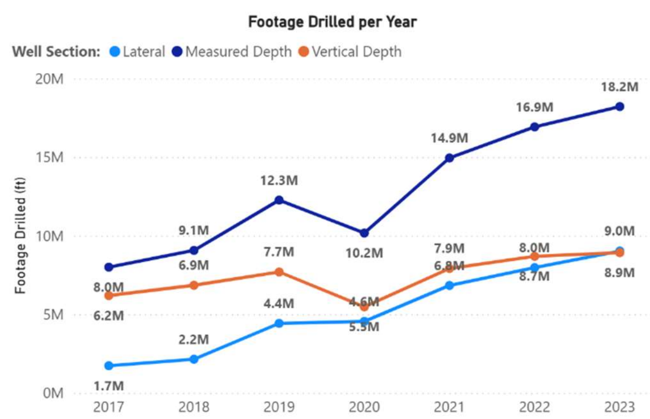

Figure 2 – Total footage drilled for wells drilled with 7-7/8"hole size by year in the Permian basin (Enverus, 2025)

This increase in footage drilled comes with a backdrop that in the past there has not been specific focus on drilling motors for this hole size. This paper reviews what has been done to address this gap. The results of which speak for themselves, as shown from the data in Figure 3. In 2017, there were very few wells drilled, if any, where the lateral section exceeded, 2 miles. By 2023, the number of 2-mile lateral sections was approximately 4.9 times that of what was drilled in 2017. 2.5-mile lateral sections which started to get drilled in 2019 grew substantially. In addition, 3-mile lateral sections were also drilled.

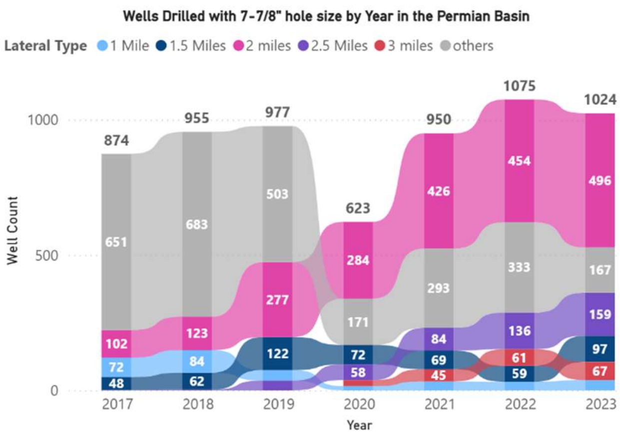

Figure 3 - Wells Drilled with 7-7/8" hole size by year in the Permian basin (Enverus, 2025)

Further within this paper, a more focused review will be done on 234 wells drilled through the years 2021 through 2025 YTD-January.

Growth of the 7-7/8" versus 6-3/4" 8-1/2", 8-3/4" hole sizes

Figure 4 below is a normalized representation of hole size footage drilled in the Permian Basin. Drilling of the 7-7/8" hole size in 2023 is 2.3 times that of 2017, and has consecutively grown year over year, except for 2020 when drilling was affected due to the pandemic. This increase in drilling of the 7-7/8" hole size is within a backdrop where the 8-1/2" and 8-3/4" hole size has reduced in footage drilled by approximately 24% and drilling in the 6-3/4" hole size has stayed relatively flat with a growth of 14%.

The paragraphs and figures above, show and make the case for improved drilling motors which enable the 7-7/8" hole sections to be drilled farther, faster and more reliably.

Drilling Motor Design – Fit For Purpose

For some time drilling the 7-7/8" hole size in the US was sporadic (this hole size is not common in other parts of the world). As a result, there was a technology gap in that there was not a drilling motor or a power section specifically designed for the 7-7/8" hole size application. During the 2020-2022 time frame, when steel and drill pipe was both difficult to find and expensive, the 7-7/8" hole size started to get more attention as it was more cost effective than drilling the 8-1/2", 8-3/4" hole size.

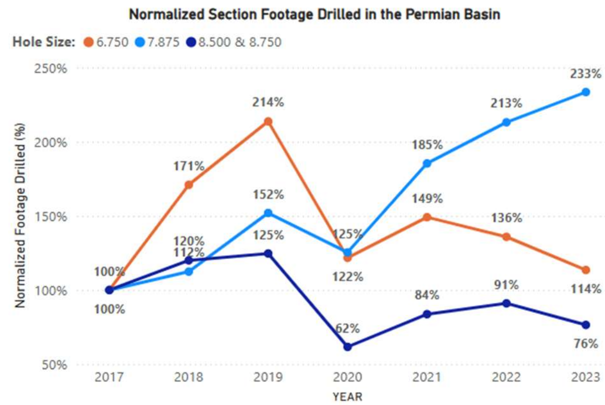

Figure 4 – Normalized hole section footage per hole size in the Permian basin (Enverus, 2025)

A specific 6-1/2" drilling motor with a specific 6-1/2" power section was developed for this growing 7-7/8" hole size application.

Prior, the well-known and used 6-3/4" 7/8 lobes 5.0 stages, or 6-3/4" 7/8 lobes 5.7 stages power sections were reduced in diameter to 6-1/2" and used in this 7-7/8" hole size application. As shown in Figure 5 both of these power sections generate approximately 363 HP at the recommended differential pressure which ranges from 1190 psi for the 5.0 stages and 1350 psi for the 5.7 stages. In addition, the torque at recommended differential pressure for these power sections, as shown in Figure 6, is 11,150 lbf-ft for the 5.0 stages and 15,200 lbf-ft for the 5.7 stages. While these power sections enabled the drillers to get the job done, the power sections were not optimized in terms of performance and reliability.

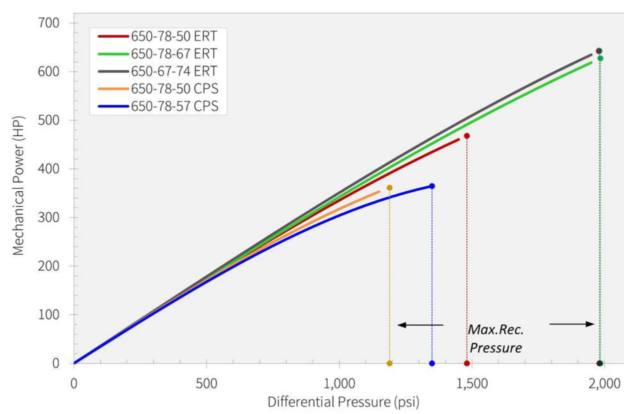

Figure 5: Drilling motor mechanical power output curves for power sections used in the Permian basin

The even rubber technology offered with the 6-1/2" 7/8 lobes 5.0 stages assisted with bridging the gap by increasing the power by 29% to 468 HP at the recommended differential pressure of 1,481 psi.

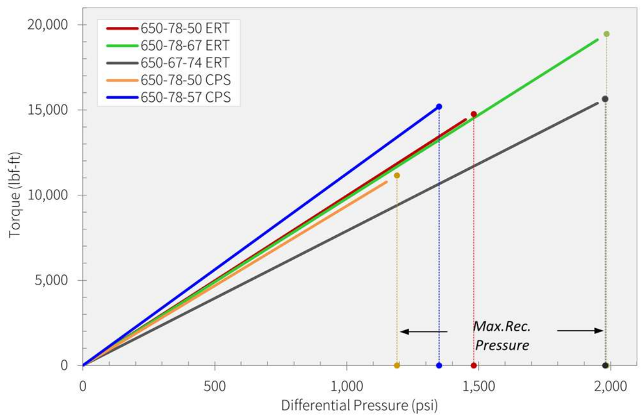

Figure 6 – Drilling motor torque output curves for power sections used in the Permian basin

Since the 7-7/8" hole size growth is mainly driven by efficiency and productivity, there was a need to push performance and reliability from the power section and drilling motor. This has been addressed with the development of a true 6-1/2" size power section in the 6-1/2" 7/8 lobes 6.7 stages even rubber technology power section. As shown in Table 1, this power section generates 627 HP at the recommended differential pressure of 1,985 psi, with a related torque of 19,462 lbf-ft. This improvement in power generated is 74% greater than what was generated with the 6-3/4" 7/8 lobes 5.0 stages, and a related 75% improvement in the torque.

The drillers, operators using this improved power section realized the value in the lateral which is evident in that from when this power section was introduced in 2021, 2022, the runs out of West Texas was 5.1 times in 2023 what it was in 2021 and 2022. In 2024, the runs out of West Texas was 11.4 times what it was in 2021 and 2022.

The .27 rev/gal speed range of this power section is ideal for the lateral section and enabled significantly improved performance. The success of this 6-1/2" 7/8 lobes 6.7 stages even rubber technology power section in the lateral with the .27 rev/gal speed range, pushed development in 2024 of a faster speed 6-1/2" power section version in the 6-1/2" 6/7 lobes 7.4 stages even rubber technology power section; this power section is 0.34 rev/gal. The power generated with the 6-1/2" 6/7 lobes 7.4 stages is 642 HP at the recommended differential pressure of 1,980 psi and torque of 15,620 lbf-ft. What the 6-1/2" 6/7 lobes 7.4 stages allows is for faster bit speed in the curve when sliding. See Table 1 for a detailed comparison of the power sections mentioned thus far.

The increased power from the even rubber technology power section versus the conventional power section is the result of the increased torque due to the ability to reliably and efficiently place more differential pressure through the even rubber technology power section, and the power section maintaining a higher speed versus conventional power sections.

	650-78-50 CPS	650-78-57 CPS	650-78-50 ERT	650-78-67 ERT	650-67-74 ERT
Diff. Pressure[1] (psi)	1,190	1,350	1,481	1,985	1,980
Torque (lb-ft)	11,150	15,200	14,749	19,462	15,620
Torque Improvement (%)	*Baseline*	*36%*	*32%*	*75%*	*40%*
Speed[2] (RPM)	170	126	167	169	216
On-Bottom Speed Improvement (%)	*Baseline*	*-26%*	*-2%*	*-1%*	*27%*
Mech. Power[3] (HP)	362	364	468	627	642
Mechanical Power Improvement (%)	*Baseline*	*1%*	*29%*	*74%*	*78%*

[1]Maximum Recommended Differential Pressure as per manufacturer specification sheet.
[2]On Bottom speed as per manufacturer speed graph, RPM taken at Max. Rec.Diff. Pressure and 700 gpm.
[3]Mechanical power output is calculated as HP = Torque x Speed / 5252.

Table 1 – Operational specification for commonly used power sections in the 7-7/8" hole size in the Permian basin (NOV, 2025)

Figure 7 shows a normalized speed graph, comparing the even rubber technology power section with a conventional power section. Each speed curve starts at 100% (off-bottom speed), then as differential pressure increases, output speed is reduced. At 100% of the recommended differential pressure of the conventional power section, the conventional power section output speed is 87%, versus the even rubber technology power section with an output speed delivering 94%.

This technological advance means that for a given power section model, the even rubber technology power section delivers higher on bottom speeds at any given differential pressure. Furthermore, the even rubber technology allows the power section to be operated at higher differential pressures, thus increasing the mechanical power output with an increase of drilling performance and reliability.

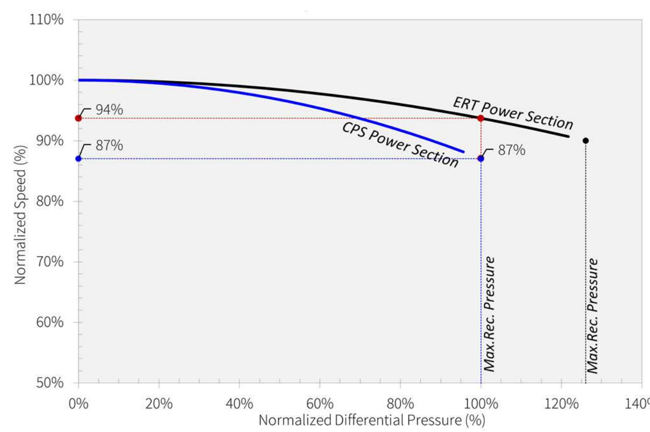

Figure 7 – Normalized speed graph comparing ERT versus conventional power sections.

The further optimization with the development and introduction of the 6-1/2" 7/8 lobes 6.7 stages and 6-1/2" 6/7 lobes 7.4 stages even rubber technology power sections enables 74% to 78% higher power output for the 7-7/8" hole size application. This higher output from the optimized even rubber technology power section needs to be matched with a focus and improvement of the drilling motor bearing pack and drivetrain.

The significantly higher torque and powerful even rubber technology power sections required a redesign of the universal joints that allow torque transmission and rotation coming from the rotor, with the new design, torque gets transferred via flat faces as shown in Figure 8 (also shown in Area B of Figure 9). These flat faces allow for a more robust system and higher torque capability compared to the traditional ball and socket design. The traditional ball and socket design tends to get worn out unequally and in the case of the significantly high torque power sections, the sockets of the driveshaft tend to get stripped due to torsional vibration and higher contact forces. In addition, as shown in Area A of Figure 9, the threaded connection of the rotor to the driveshaft is tapered and double shouldered to be able to handle significantly higher torques.

Figure 8 – Driveshaft detailing the universal joint and the flat face torque transmission technology.

Moving closer to the bit box and into the bearing assembly of the drilling motor, as shown in Area C of Figure 9 the bearing adapter connection to the bearing mandrel is more closely supported by a set of upper radial bearings which have a dual purpose of also being the upper flow restrictors. To increase robustness of the bearing assembly the bearing mandrel is stepped (as shown in Area D) through its length to allow for the more strength and robustness closest to the bit box.

There is a set of lower radial bearings / flow restrictors, closer to the bit box (as shown in Area E). In between the upper and lower radial bearings / flow restrictors, there is a bearing stack which is there to primarily take the axial load. The bearing stack also significantly improves radial support and overall robustness of the bearing assembly. Towards the end of bearing mandrel and before the bit box there is a mandrel catch.

The Series 55RS is specifically designed for motorized rotary steerable assist applications, where higher torque power sections are desired to drive the steering BHA below the drilling motor. In order to reliably transfer torque, the drivetrain is further optimized as a hybrid flexshaft, as shown in Area G of Figure 9, with an integral upper connection that directly threads to the rotor. As shown in Area F of Figure 9, the upper universal joint is removed, thereby reducing subcomponents and potential failure points. By increasing the overall length of the driveshaft and an optimized material selection, the Series 55RS drivetrain has the balance of required flexibility and overall robustness to reliably transfer motion and torque to the bearing assembly.

In addition, with the Series 55RS, the bearing assembly design has been optimized to offer extended run life and reduce the wear of key components such as the bearing stack races and radial support flow restrictors as shown in Area H and Area I of Figure 9. Including additional races and ball bearings in the bearing stack allows 31% higher axial load capacity.

Flow bypass components that control lubrication of the bearing stack have been optimized in line with the need to maximize hydraulics below the drilling motor. A 36% increase of radial support allows the drilling motor to maintain better control of the fluid flow through the flow restrictors and additional radial support. These features are critical in maintaining an optimized flow restrictor clearance and radial stability in extended reach motorized rotary steerable assist applications.

	Series 55[1]	**Series 55RS[1]**
Size	6 1/2 in	6 1/2 in
Bit to bend (Fixed)	53.4 in	n/a
Bit to stator	81.9 in	131.0 in
Max WOB @100RPM	93,000 lbf	121,300 lbf
Pull to re-run	199,000 lbf	294,200 lbf
Radial Load Capacity[2] (%)	*Baseline*	*136%*
Axial Load Capacity[3] (%)	*Baseline*	*131%*

[1] Source: Published manufacturer specifications.
[2] Load capacity is a function of total flow restrictor carbide surface area.
[3] Load capacity improvement at dynamic conditions while tagging bottom and rotation.

Table 2 - Specifications for the 6-1/2" bearing packs

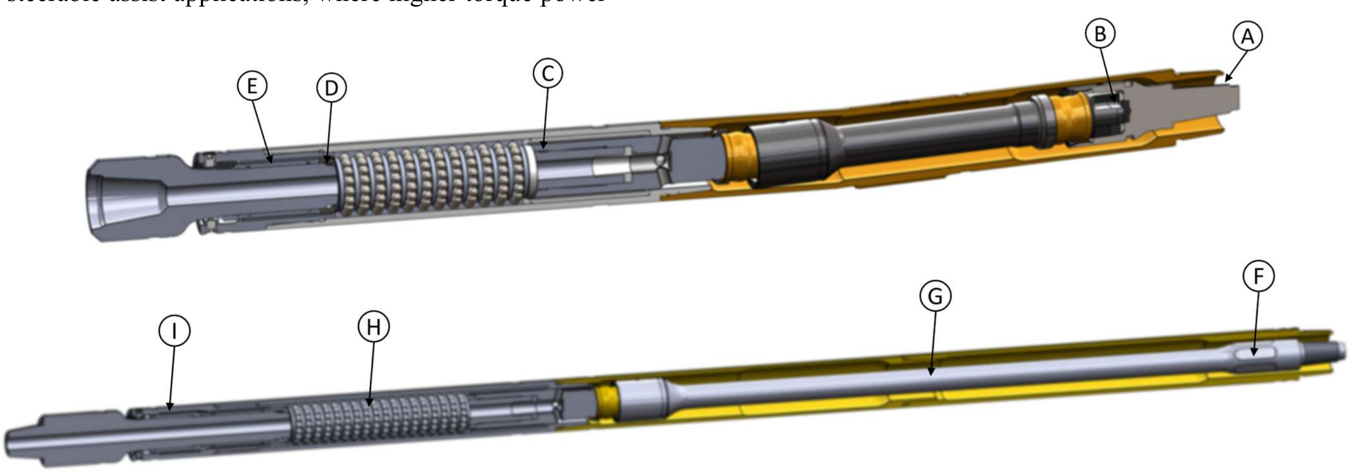

Figure 9 – Detailed view of the 6-1/2" Series 55 (top), and Series 55RS (bottom) bearing packs.

Performance Study for Permian Data Subset

Table 3 summarizes the average run footage and average run ROP for 234 runs in the Permian basin during the period of 2021 through 2025YTD-January with the Fit For Purpose Drilling Motor for the 7-7/8” hole section which is the subject of this paper.

Year Group	Average Run Footage (ft)	Average Drilling ROP (ft/hr)	Run Count
2021-2023[1]	4,883	98	65
2024-2025 (YTD-Jan)[1]	6,628	126	169

[1]*Data Source: Data extracted from Run Motor Reports used in each period.*

Table 3 – Drilling motor run data summarized by year groupings

These runs are further shown in Figure 12 specifically for the 2021-2023 time frame, and Figure 13 specifically for the 2024-2025YTD-Jan time frame. The data is from multiple operators drilling their 7-7/8” hole sections with aforementioned Fit For Purpose Motors, where the run information and well name code was available. The well name code was used to obtain the well lateral length. The analysis of this data is as follows:

For the time frame 2021 through 2023 with a run count of 65. The average run footage drilled was 4,883 ft, with the highest run footage at 10,158 ft. The average run ROP was 98 ft/hr, with the fastest run ROP at 269 ft/hr. Within this data set the most common well lateral length was the 1.5-mile and 2-mile as seen in Figure 10, each with a count of 22. The 3-mile well lateral length had a count of 11. This is within a backdrop as shown in Figure 3, where prior to 2020, records do not show a well 3-mile lateral in the 7-7/8" hole size to be drilled in the Permian basin.

For the time frame 2024 through 2025YTD-January with an increased run count of 169:

The average run footage drilled increased to 6,628 ft, with the highest run footage at 16,198 ft.

The average run ROP increased to 26 ft/hr, with the fastest run ROP at 361 ft/hr.

Within this data set the most common well lateral length was now the 2-mile, with a count of 64. The 3-mile well lateral length had an increased count of 27.

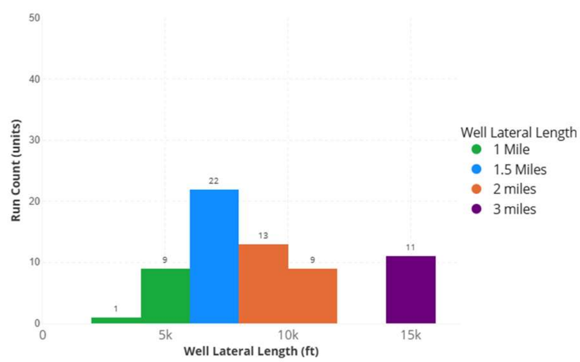

Figure 10 – Lateral length distribution for performance subset data, wells drilled between 2021-2023. (Enverus, 2025)

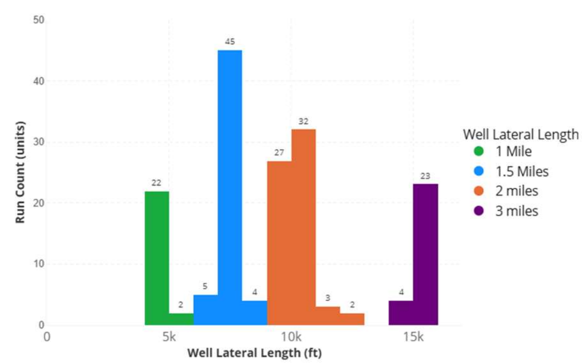

Figure 11 – Lateral length distribution for performance subset data, wells drilled during 2024 to 2025-YTD January. (Enverus, 2025)

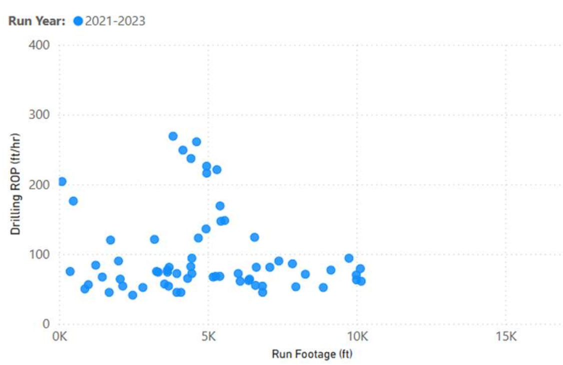

Figure 12 – Rate of penetration as a function of Footage drilled per run. Wells drilled between 2021 and 2023 in the Permian.

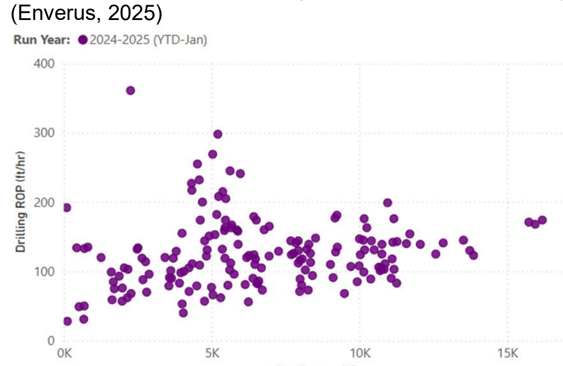

Figure 13 – Rate of penetration as a function of Footage drilled per run. Wells drilled in 2024 and 2025 (YTD January) in the Permian.

Conclusions

By developing a true 6-1/2" drilling motor and fit for purpose matching power sections, the study demonstrates significantly improved drilling performance compared to using downsized 8-1/2" and 8-3/4” hole section drilling motors.

The even rubber technology power sections generated between 74% to 78% more mechanical power than conventional counterparts, enabling higher on bottom torque and speed. The redesigned bearing pack and drivetrain, featuring flat face universal joints, and increased radial and axial load capacities,

improved drilling motor reliability in extended-reach laterals.
A dataset of 234 runs in the Permian basin from 2021 through early 2025 shows a marked improvement in single-run footage and average rate of penetration, especially in laterals exceeding two miles. Several runs surpassed 10,000 ft, illustrating the drilling motor's capability to drill longer intervals and reduce total drilling time.
As lateral lengths in the Permian continue to increase, these purpose-built motors have become a preferred choice, balancing power, speed, and durability.
The success of the 0.27 rev/gal power section in the lateral has driven demand for a faster (0.34 rev/gal) version better suited for curve-lateral combination drilling. Ongoing optimization of the power section, bearing assembly, and drivetrain materials will further enhance drilling efficiency, reduce non-productive time, and expand application beyond the Permian.
Overall, the development of a fit for purpose 6-1/2" drilling motor for the 7-7/8" hole size represents a significant leap forward in bridging long-standing performance and reliability gaps. Field results confirm that targeted engineering solutions, rather than scaled-down designs, are essential to meet the demands of extended-reach wells and continuously evolving drilling programs

Acknowledgments

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Nomenclature

BHA = Bottomhole Assembly
RSS = Rotary Steerable System
CPS = Conventional Power Section
ERT = Even Rubber Technology
YTD = Year to Date
HP = Horsepower
ROP = Rate of Penetration
WOB = Weight on Bit
RPM = Rotations per Minute
psi = Pounds per Square Inch
rev/gal = Revolutions per Gallon
in = Inch
ft = Foot or Feet
ft/hr = Feet per Hour
lbf-ft = Pound-Force Foot

References

Enverus Intelligence Research, Inc. 2025, "Exploration & Production Database." https://www.enverus.com/solutions/energy-analytics

NOV Inc. 2025, "Power Sections App, Power Section Specification Sheets." https://www.nov.com/products/drilling-power-sections