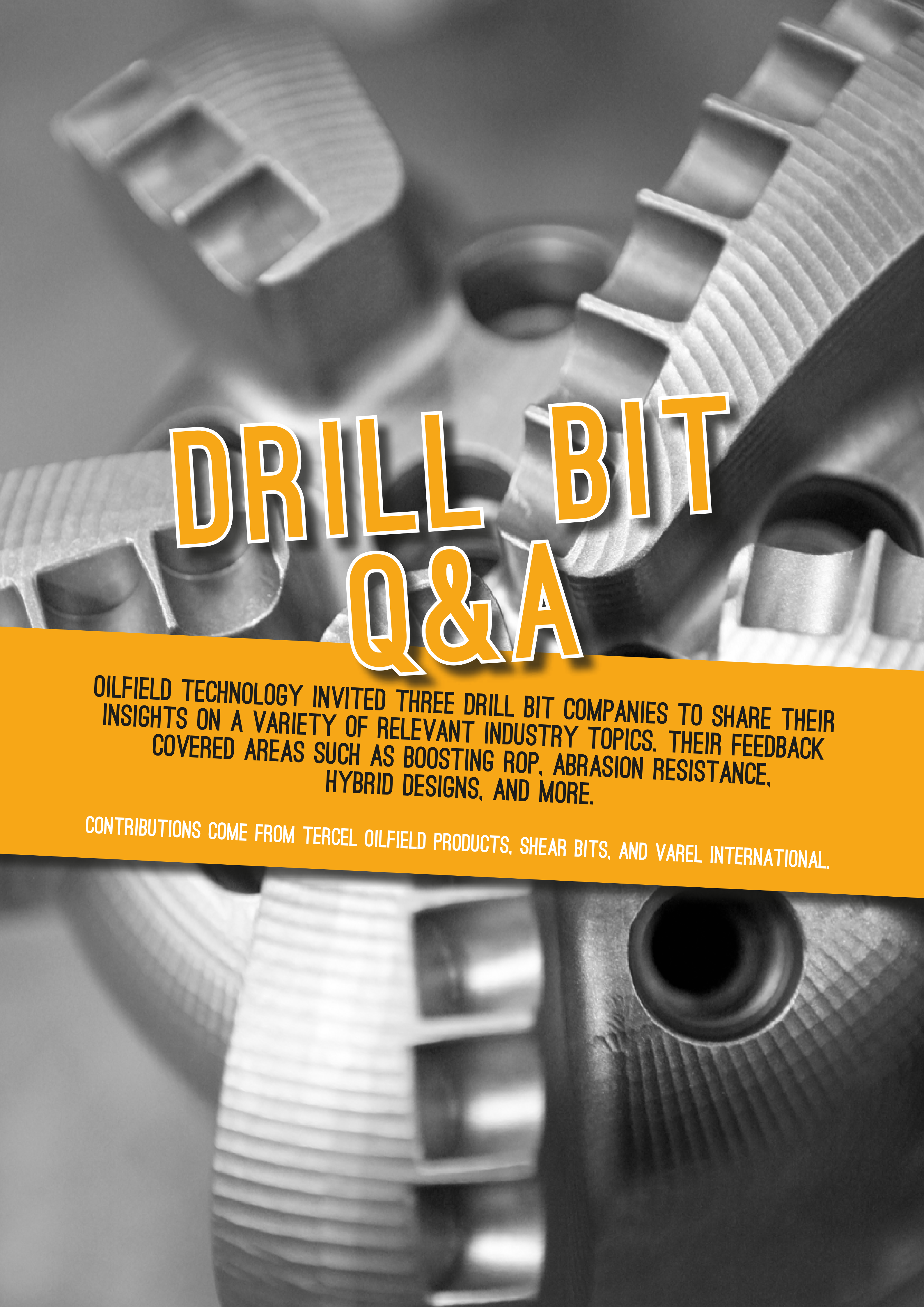

DRILL BIT Q&A

OILFIELD TECHNOLOGY INVITED THREE DRILL BIT COMPANIES TO SHARE THEIR INSIGHTS ON A VARIETY OF RELEVANT INDUSTRY TOPICS. THEIR FEEDBACK COVERED AREAS SUCH AS BOOSTING ROP, ABRASION RESISTANCE, HYBRID DESIGNS, AND MORE.

CONTRIBUTIONS COME FROM TERCEL OILFIELD PRODUCTS, SHEAR BITS, AND VAREL INTERNATIONAL.

DRILL BIT Q&A

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Advances in PDC Technology

An interesting situation has developed in the oil and gas drill bit industry, specifically with regard to PDC cutter development. The typical development process for any new PDC cutter technology is naturally very complex. Despite the fact that the industry has spent the past 30 - 40 years attempting to develop laboratory scale testing that can simulate the results of actual field tests, the variability of real world applications still cannot be fully replicated in a laboratory environment. Therefore, no matter what level of R&D or laboratory experimentation is undertaken to develop new technology, the ultimate test of validity is in the downhole environment. Unfortunately, during 2015, when drilling activity declined at such a rapid pace, it left larger service companies with excessive inventory levels of PDC cutters. That situation, coupled with the greatly reduced availability of drilling programmes, equated to a tremendous slowdown in field-testing opportunities and subsequently in the speed of PDC cutter development at major service companies.

One example of a process that is still returning performance advances can be found at a smaller, independent service company focused on developing new technologies that deliver value to oil and gas operations. Partly out of necessity, and partly as an overall strategy to accelerate development, Shear Bits approaches carefully analysed and planned field trials as quickly as possible. A recent result of this process was field record performance in a highly challenging horizontal application. The formation is composed of fine grained siltstones, with calcareous shale inter beds, and the application presents thermal, abrasion and impact challenges for PDC cutters. Previously, the leading performance in the field was with premium deep leached cutter technology from a major service company. Using new PDC cutter technology that significantly enhances thermal stability compared to conventional non-leached cutters, the 6 ¼ in. SH513E PDC drill bit (Figure 1) was able to drill the longest interval for the operator at a higher ROP than all of the shorter runs in the application (Figure 3).

Figure 1. *Dull condition of 6 ¼ in. SH513E PDC drill bit after drilling 1754 m in a challenging horizontal interval.*

Hybrid designs

The first designs of PEXUS™ hybrid bits were targeted at applications where conventional PDC bits are ineffective, such as drilling gravel, boulders or other conglomerates that typically destroy PDC cutters. The hybrid cutting structure includes large gouging inserts that are not part of a conventional fixed blade structure preceding a more typical blade of PDC cutters. This construction proved to be extremely effective in drilling challenging lithologies at a high ROP without suffering damage to the PDC cutters. In addition to providing enhanced durability, it was discovered that this cutting structure configuration also produced smooth torque response equating to superior directional behavior compared to conventional PDC bits.

In an effort to expand the benefits of the technology into more applications, a new concept has been developed. Unlike earlier designs that were focused on expanding the application range of fixed cutter bits through added toughness, the new concept focuses on delivering a faster rate of penetration to enhance performance in existing PDC bit applications. The first design in this new series is the 12 ¼ in. SVP419 (Figure 2) which includes four blades of 19 mm diameter PDC cutters with large gouging inserts in the middle of the waterways between the fixed blades. This new layout allows the hybrid cutting structure to drill as fast as, or faster than conventional PDC bits, while delivering more consistent toolface control and improved toughness in challenging formations. The first run with the new design was recently completed in a surface interval with some gravel in the upper portion of the section and included instantaneous ROP values over 700 ft/hr. The average ROP for the interval was as fast as any PDC bit run in the area, and the dull was found to be in excellent condition, with no broken PDC cutters. The run was conducted with a conventional directional assembly with a 1.83˚ bent motor, and the new hybrid bit responded very well to directional requirements.

Advanced material selection

Two of the most challenging applications in the world for drill bit bodies are drilling oilsands, and drilling in situations where the mud (drilling fluid) contains high solids content. In both of these examples, the bit body is exposed to an environment that is not dissimilar to sand-blasting or media-blasting. In oilsands applications, the formation is typically very soft and unconsolidated, but contains abrasive sands that are easily entrenched in the drilling fluid, which is ultimately similar to scenarios where the drilling mud contains a high percentage of abrasive solids. Until quite recently, only matrix-bodied bits were used in these applications due to the enhanced wear resistance of the tungsten carbide matrix construction in comparison to steel-bodied bits. However, with the introduction of composite-bodied bits in 2012, Shear Bits changed that equation and proved that composite-bodied bits outlasted both matrix-bodied and steel-bodied bits in the world's most challenging environments.

Despite the fact that composite-bodied bits have conclusively proven to be superior to all other construction techniques, in the most severe environments, body wear remains an issue to be addressed. Working in conjunction with a leading supplier of wear resistant surface coating technologies, further improvements have been realised through the development of advanced formulations of tungsten carbide hard metal coatings. The new wear resistant layer now contains nearly 50% more carbide than is found in matrix-bodied bits with additional abrasion resistant components to enhance wear life. In one very challenging horizontal application, where the gage pads of the bit are under constant loading against highly angular sands, the new material proved to substantially reduce material loss compared to previous materials. The images in Figure 4 are from the same bit (identical serial number) used on the same pad with the same rig, same operator, same BHA and same operating parameters. The results, therefore, are as applicable as can be found in any field trial situation. As seen in the images, the leading edge of the gauge pad with the existing material suffered complete loss of the protective coating, while the new material held up effectively.

Boosting ROP

Over the past 30 years, there has been a consistently growing trend in the industry to replace rollercone bits with PDC bits, primarily due to the fact that PDC bits tend to drill further and faster than rollercone bits. In the mid 1980s, a very small percentage of applications were drilled with PDC bits, but today PDC bits reportedly drill over 85% of the total footage in oil and gas wells. Of the remaining 15% of applications, there are many situations where PDC bits are completely ineffective due to the formations encountered. In those applications, ROP tends to be low due to the drilling mechanism of rollercone bits, and therefore an opportunity exists to increase performance and deliver cost savings in these challenging intervals.

In one such application, drilling a surface hole interval through heavy gravel that quickly renders conventional PDC

Figure 2. *12 ¼ in. SVP419- Pexus Hybrid Drill Bit.*

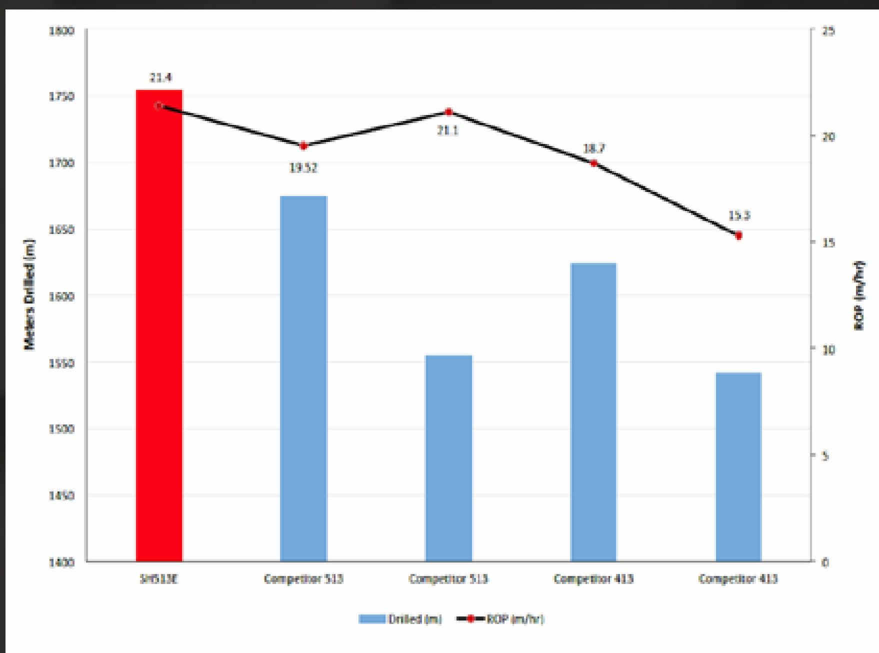

Figure 3. *Relative performance of the 6 ¼ in. SH513E PDC drill bit with new PDC cutter technology.*

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Figure 4. *Comparative gage pad wear for three runs of the same bit in the same application with diferent coating technologies.*

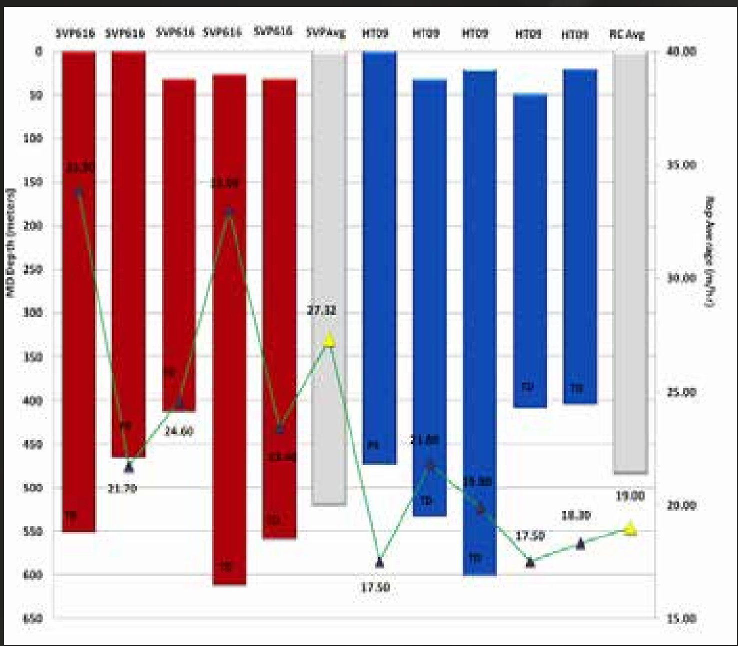

Figure 5. *Relative performance of Pexus Hybrid Drill Bits compared to Rollercone Bits.*

Figure 6. *Resulting carbide substrate condition after drilling 8 legs of an oilsands well with a 7 ⅞ SH513D PDC drill bit.*

bits damaged beyond repair, the highest average ROP achieved with rollercone bits over the course of hundred of wells of development was only 19 m/hr. Through the introduction of the company's hybrid bit technology, it was possible to increase the average ROP in this interval by nearly 50%, while simultaneously drilling an average distance that was over 10% further than that with rollercone bits. This same performance advantage has been seen in many surface hole applications that contain heavy gravel. The hybrid gouging/shearing cutting structure produces much higher ROP than rollercone bits without suffering damage to the PDC cutters as would happen with conventional PDC bits (Figure 5).

Abrasion resistance

One subject that is often overlooked with respect to PDC bit performance is the effect of the wear resistance of the carbide substrate on PDC cutter durability. With the invention of composite-bodied PDC bits in 2012, a new level of wear resistance was introduced to drill bit bodies in some of the most extreme applications in the industry. However, despite the fact that body wear was virtually eliminated in many applications, the carbide substrate on the PDC cutters themselves continued to suffer extreme material loss. When carbide substrate wear is severe enough, it can lead to either cutter loss (due to compromising the braze joint) or to cutter breakage (due to reduced support for the diamond table), and in rental markets, can quickly render otherwise successful performance uneconomical.

Unfortunately, merely identifying that carbide substrate wear was the new weak link in PDC bit durability did not offer immediate solutions as the carbide substrate, in many situations, has gone virtually unchanged for decades. In the pursuit of continually improved toughness, abrasion resistance and thermal stability, PDC cutter technology development has become an almost impossibly complex mixture of extreme materials and processes. Therefore, changing the carbide substrate, which is a cornerstone of PDC cutter construction, was generally not considered a viable option by most PDC cutter manufacturers.

Working closely with an industry leading supplier of PDC cutters, the company developed HARD Cutters™, a technology that has addressed carbide wear in some of the world's most extreme environments. As seen in Figure 6, the primary row of PDC cutters are HARD Cutters, and the backup row of PDC cutters are conventional PDC cutters. Despite the fact that the primary cutters are longer, and therefore more carbide is exposed to wear, and despite the fact that fluid velocities are much higher around the primary cutters, it can plainly be seen that the material loss of the conventional PDC cutters is quite severe, while there is very little carbide wear at all on the HARD Cutters. ■