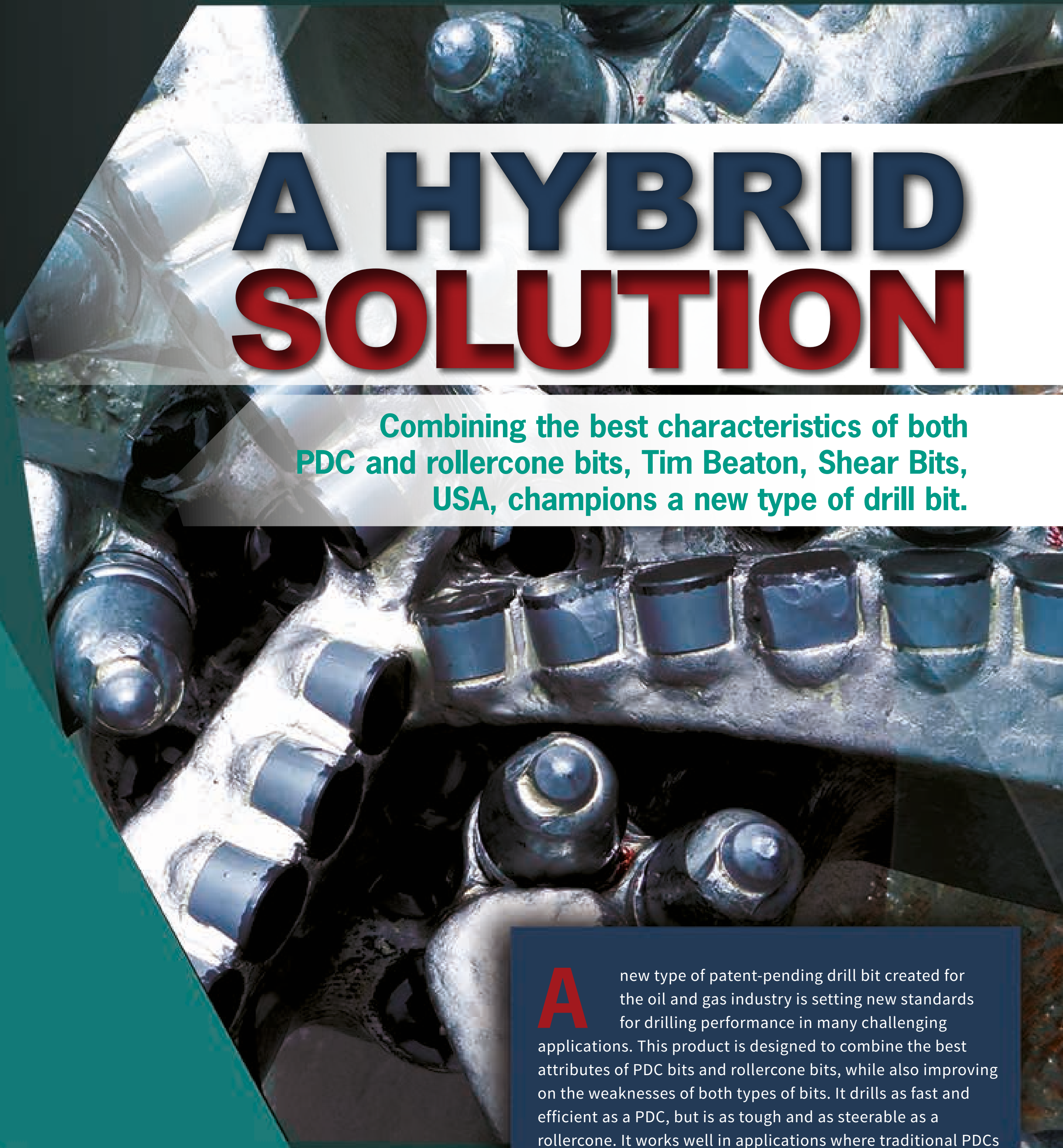
A HYBRID SOLUTION



Combining the best characteristics of both PDC and rollercone bits, Tim Beaton, Shear Bits, USA, champions a new type of drill bit.

A new type of patent-pending drill bit created for the oil and gas industry is setting new standards for drilling performance in many challenging applications. This product is designed to combine the best attributes of PDC bits and rollercone bits, while also improving on the weaknesses of both types of bits. It drills as fast and efficient as a PDC, but is as tough and as steerable as a rollercone. It works well in applications where traditional PDCs are commonly damaged beyond repair while retaining the durability to complete long intervals with no risk of bearing or seal failures. Even in very large hole sizes, these bits behave very smoothly on rotary assemblies and consistently on directional assemblies.

Shear Bits' new hybrid gouging/PDC bits include two very different yet totally complete cutting structures (Figure 1). The primary cutting structure is comprised of gouging inserts that are secured to the bit in such a way as to allow them to revolve while drilling, which greatly enhances wear resistance, and the secondary cutting structure is an aggressive shear cutter arrangement. The two layouts are completely independent of one another, yet work effectively together to improve drilling performance in a wide variety of applications.

Background

Rollercone bits have been in use for well over 100 years in the oil and gas industry and, while the percentage of footage drilled by PDC bits has grown dramatically in the recent past, there remain many applications where rollercones are still the top performer. Rollercones fail the rock primarily through a crushing action, and as a result are very capable products when drilling through challenging formations such as chert, pyrite, gravel or boulders (Figure 2). Also, since the cutting elements are mounted on rotating cones, the torque signature of a rollercone tends to be consistent, even when drilling through formation transitions or in the presence of erratic operating parameters.

Figure 1. *12 ¼ in. SVP616 hybrid gouging/PDC drill bit.*

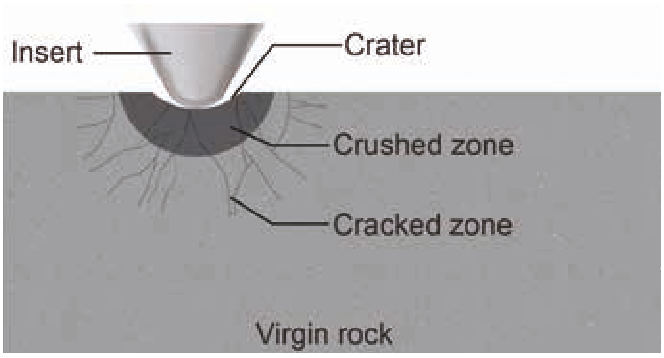


Figure 2. *Crushing cutting mechanism and resulting rock condition.*

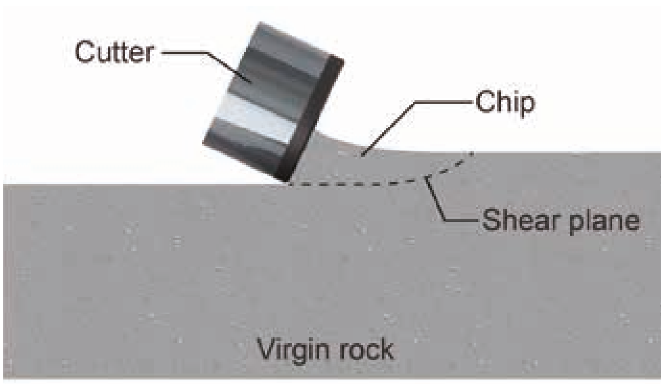


Figure 3. *Shearing cutting mechanism and resulting rock condition.*

PDC bits were introduced in the 1970s and quickly became the top performer in many soft and homogeneous formations around the world due to their efficient shearing action (Figure 3). PDC bits are also favoured in many applications that require, or at least benefit from, longer run lengths. Because a PDC bit has no moving parts, there is no risk of mechanical failure as there is with a rollercone, and therefore PDCs can stay in the hole for an extended period of time. Rollercones are commonly pulled at a given amount of operating hours in order to prevent bearing or seal failures, which can create a situation where multiple bits and multiple trips are required to complete a given interval, but PDC bits are able to stay in the hole for an indefinite period as long as the PDC cutters stay sharp.

Due to advancements in PDC cutter technology that inhibit cutter wear, PDC bits have become the product of choice in the vast majority of oilfield applications around the world.[1] The applications where rollercones are still the top performer can be broken down into two parts: formation considerations and drilling behaviour.

Rollercone applications that are formation-related include rock types that can quickly destroy PDC bits. This generally includes formations that have conglomerates, gravel, boulders, chert or pyrite (Figure 4). Because PDC cutters are made of diamond and have a planar cutting face, they have exceptional wear resistance, but limited toughness, especially compared to the type of inserts commonly used in rollercones. As a result, when PDC cutters encounter the formation types listed above, they typically break very quickly, which can frequently lead to irreversible damage of the bit body. Conversely, rollercones are remarkably tough and commonly drill these types of formations without any issues or significant damage, due to the fact that the cutting elements are generally made of carbide, not diamond, and are typically more blunt in geometry than shear cutters.

Because the cutting elements on a rollercone crush the formation as each element rotates around into position on the cone, and since the cones are free to rotate in any direction at any time, at any speed, rollercones generally exhibit very smooth drilling behaviour (very little reactive torque). Conversely, because PDC bits have fixed blades and the cutters are in fixed positions, the drilling behaviour of a PDC bit can be quite erratic with respect to torque response (high reactive torque). In many applications, operators have become accustomed to this difference in behaviour in order to reap the benefits of PDC bits in terms of a high rate of penetration (ROP) and long runs. However, erratic torque response can be especially detrimental when drilling large hole sizes or in challenging directional applications.

Logically, the torque required to drill a given formation is relative to the size of the hole being formed. Smaller diameter boreholes are created by smaller diameter bits and, therefore, have less torque associated with the operation. However, large diameter bits (especially bits larger than 17 ½ in. diameter) generally drill with much greater torque in order to remove a larger quantity of rock. Higher torque can be managed as long as it is consistent, but with large diameter PDC bits, this generally has not been the case. For these reasons, most boreholes drilled around the world that are larger than 17 ½ in. diameter are typically drilled using rollercones, to take advantage of their inherently smooth drilling behaviour.

A similar situation exists in the world of directional drilling. In a large percentage of applications, the industry has become accustomed to the torque response of a PDC bit in order to achieve faster penetration rates and longer run lengths, but it is still widely accepted that rollercones are much easier to control on directional assemblies. For this reason, many complex directional programmes still heavily utilise rollercone bits. The potential loss of ROP and run length is offset by the importance of accurately maintaining the directional well plan.

The best of both worlds

The company's new hybrid bits combine the benefits of PDCs and rollercones to produce enhanced drilling performance. The primary cutting structure fails the rock through a gouging method that is relatively new and unique to the oil and gas industry (Figure 5). Gouging is not a new concept to the world of rock removal as it is heavily utilised in other industries, such as mining and road milling, but it is a method that had seen little use in the oilfield until Shear Bits introduced the earliest versions of its hybrid bit in late 2013. The late entry of a gouging cutting structure into the oilfield is due to the fact that it is generally not durable enough to drill a significantly long section in an oil or gas well. As with most attempts to utilise mining bits for drilling oil and gas wells, early tests with gouging bits met with very limited success, with bits becoming damaged beyond repair in very short intervals, commonly less than 150 m (500 ft). The answer to this problem was demonstrated with the development of a hybrid gouging/shear cutter bit in the autumn of 2013. By combining two totally different cutting mechanisms into one drill bit, a new product was invented that has since proven to be in a class of its own for drilling performance. The gouging mechanism of rock removal has proven more efficient than shearing, mainly due to the large cracked zone that is created when the conical tip of the gouging cutter penetrates the rock. These fractures release larger cuttings than shearing and therefore can remove rock even faster than shearing. The gouging cutters are also extremely tough and protect the shear cutters from damage when drilling through challenging lithologies. Finally, although the gouging cutters are free to rotate while drilling, there are no seals or bearings to fail like in a rollercone, and cutting tips are designed to wear so that they are even with the shear cutters long before significant wear occurs to any of the mating surfaces for the rotating parts. Once the gouging cutters wear even with the shear cutters, the rotation of the parts is negligible, thus eliminating any issues with wear to the moving parts throughout the rest of the run.

The very first application of the new hybrid bit was in Western Canada in an application known for severe gravel and boulders. This is the same application that produced the PDC bit dull shown in Figure 4. As seen in Figure 6, the size of the gravel/boulders in this application was extreme, which is why all previous successful intervals were completed with rollercones (the rocks in these images are actual samples captured at surface). Any attempts made with PDC bits in this application quickly suffered the same fate as the bit shown in Figure 4. The first test runs completed with the first new bit, a 14 ¾ in. diameter SVP619, included three consecutive wells drilled on the same pad, with the same bit, without any repair to the PDC cutting structure (the gouging cutting elements were changed out in the field in-between wells). In each run, the ROP was limited due to the ability of the surface equipment to handle the cuttings generated by the hybrid bit, which experienced instantaneous ROP values of over 300 m/hr (1000 ft/hr). After the first well was drilled, the

Figure 4. *Gravel damage on a conventional large diameter PDC bit.*

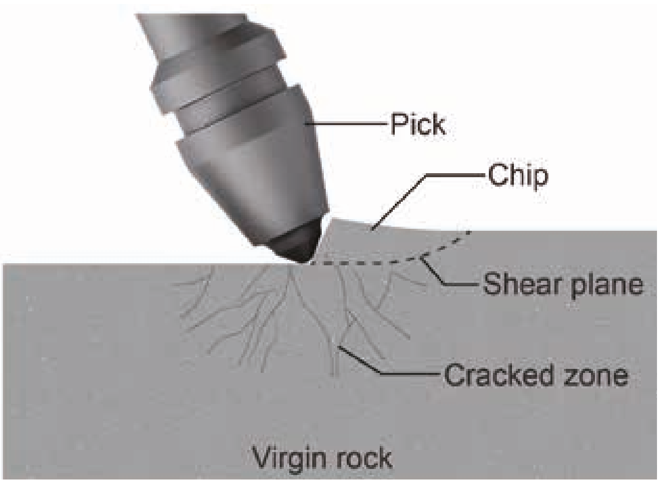


Figure 5. *Gouging cutting mechanism and resulting rock condition.*

Figure 6. *Rock samples from the first wells drilled by the new hybrid gouging/PDC bits.*

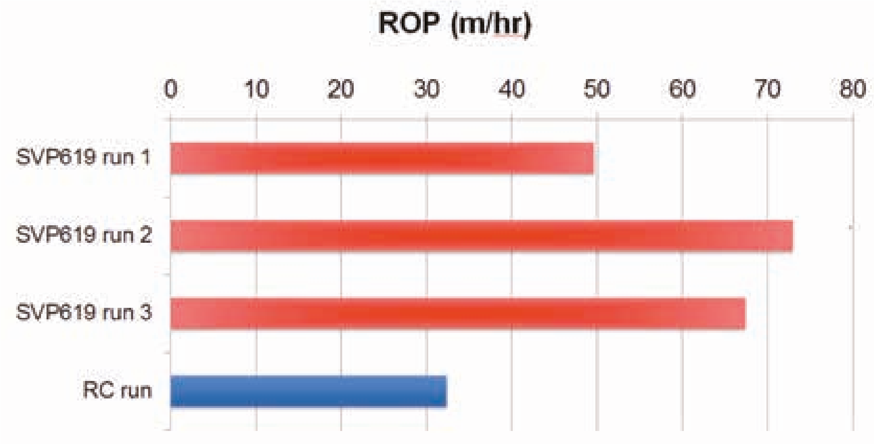


Figure 7. *Drilling performance for initial hybrid bit runs.*

Figure 8. *14 ¾ in. SVP619 dull condition.*

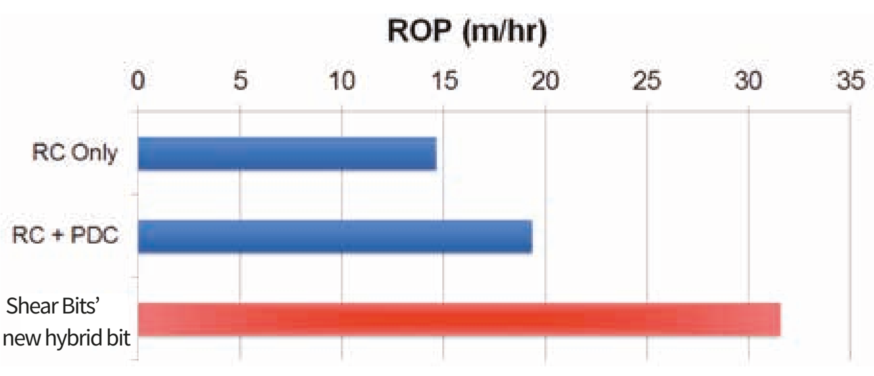


Figure 9. *Performance data from 12 ¼ in. SVP616 runs near the foothills of the Canadian Rockies. All runs drilled ~ 600 m (2000 ft), results are an average of 24 offset wells. Additional hybrid bit runs have been completed in this area in less than 19 hours, with the fastest to date at 13 hours.*

surface equipment was updated, which allowed subsequent wells to be drilled at a higher ROP, although they were still control drilled (Figure 7). In each of the three wells drilled by the bit, the dull condition was excellent (Figure 8), with minimal to no damage to the PDC cutting structure, even in the presence of rocks that had destroyed traditional PDC bits in offset wells. The four-well pad was completed using a rollercone for the last well in order to provide accurate comparison to historical wells, and the rollercone performed consistently with offset wells, proving the ROP benefit of the new hybrid bit.

Since that first pad, over 100 000 m (330 000 ft) of rock has been drilled with Shear Bits' hybrid bit in a variety of applications in a variety of hole sizes, from 9 ⁷/₈ in. to 24 in. diameter. The development of this technology has been rapid and primarily targeted to situations either where rollercones are too slow or where PDCs generally take too much damage to be effective. The majority of the runs completed to date have been in Western Canada drilling surface hole intervals. In the Western Canadian sedimentary basin, there is a large percentage of applications that drill surface through glacial till laid down when the Canadian Rockies were formed. The result of that geological process is that the upper section of many surface intervals must be drilled through a section heavy with gravel or boulders. Consequently, most wells are drilled with a rollercone for approximately the first 150 m (500 ft), at which point the rollercone is pulled in favour of a PDC that will finish the interval at an ROP that is commonly 2 - 5 times faster than that achieved by the rollercone. In one specific region of western Alberta, near the foothills of the Rocky Mountains, drilling activity has been busy for many decades, and nearly all 12 ¼ in. diameter surface applications have been drilled with this strategy of one rollercone to drill through the gravel and then one PDC to complete the surface interval to approximately 600 m (2000 ft). In a 6 mile radial search around one location, 24 wells were studied to compare the performance of various drilling strategies. As seen in Figure 9, the performance of the 12 ¼ in. SVP616 (Figure 1) in this application has been impressive – sometimes completing surface intervals nearly three times faster than when using conventional drill bits, not including the savings and safety advantages associated with eliminating a trip.

In addition to the ability to drill further and faster through difficult lithologies, the new hybrid bit also provides a much smoother torque response than a PDC bit without sacrificing ROP. This is probably best demonstrated by the performance of these products in large hole sizes. To date, the largest hybrid bit produced has been 24 in., but there is capacity to produce bits in any size commonly used in the industry, up to 48 in. diameter. In the runs completed to date with 24 in. bits, some remarkable performance has been achieved. Probably the most surprising aspect has been the smooth drilling behaviour shown by the 24 in. SVP616D (Figure 10). Some of the runs completed have been on directional assemblies to provide the ability to nudge the wellbore to create spacing on tight pads. In these situations, the large diameter SVP616D performed excellently, allowing the directional team to achieve consistent slides, as seen in Figure 11. This is an actual photo of a toolface plot taken during one of the runs with the 24 in. bit, and this type of smooth behaviour was seen throughout the runs, not just on this one slide. In addition to drilling smoothly, the new hybrid bit also drilled at a very high ROP. In the case of one pad, one of the wells was drilled with rollercones only, and two of the wells were drilled with a combination of rollercones and hybrid bits. As seen in Figure 12, the wells drilled with hybrid bits were able to reach TD much quicker than the well that only used rollercones. Many other runs have been recorded in other hole sizes on directional assemblies with similar results. In all situations, the steerability of the new hybrid bit has proven to be a substantial improvement over conventional PDCs, allowing the directional team to more consistently follow the intended well path without sacrificing ROP.

Conclusion

An entirely new type of bit has been developed for drilling oil and gas wells. This novel hybrid design combines the best attributes of PDC bits and rollercone bits without being subject to the weaknesses of either conventional type of drill bit. The result is a product that is as reliable as a fixed cutter bit and drills as fast and as far as a PDC, yet is as tough and smooth as a rollercone. Extensive, rapid development of this new technology has already produced record-breaking performance in many hole sizes and in many applications, while barely scratching the surface of the worldwide market so far. Many developments are underway to bring this new technology to additional challenging applications in an effort to improve drilling performance, reduce well costs and increase safety in drilling programmes around the world.

Figure 10. *24 in. SVP616D hybrid gouging/PDC drill bit.*

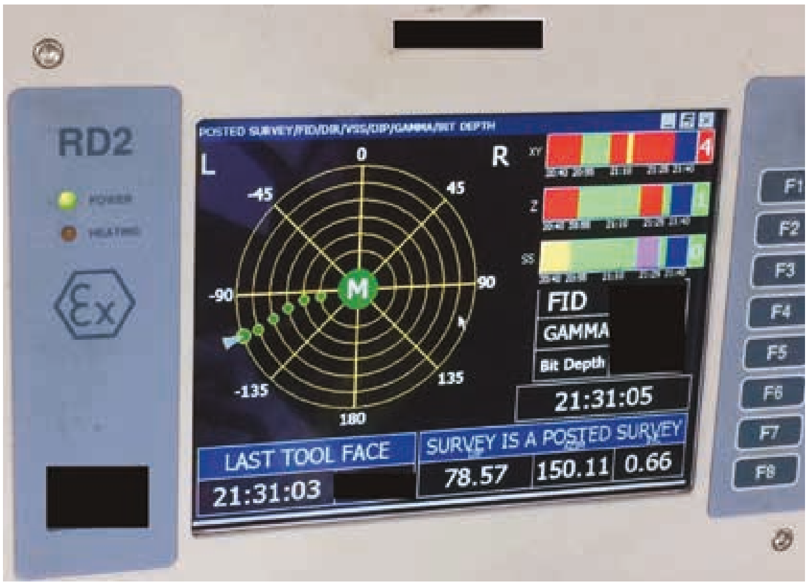


Figure 11. *Photograph of toolface plot during a directional run with the 24 in. SVP616D.*

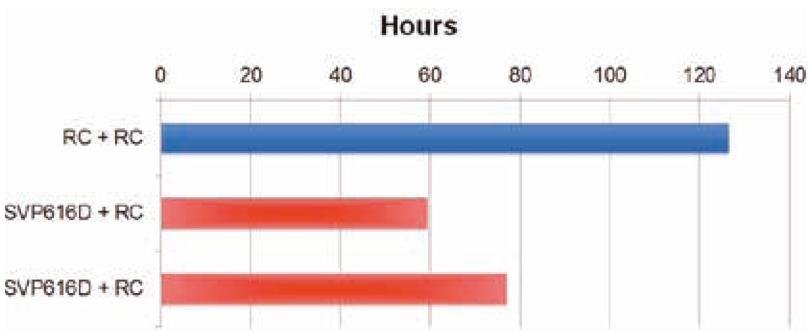


Figure 12. *Performance data for 24 in. SVP616D bit runs. All runs were on the same pad and drilled ~ 600 m (2000 ft). Both rollercones from the first well were destroyed. Both hybrid gouging/PDC bits run in successive wells were repairable.*

Reference

1. Beaton, T., 'When the going gets tough, the tough get going', Oilfield Technology, (February, 2014), p. 20.