Drilling Straight Down

Rotary steerable drilling technology continues its rapid evolution with a new system created specifically for vertical drilling.

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2. "Drilling Levels Will Continue Upward," *World Oil* 225, no. 2 (February 2004): 41, 43–45, 47.
   "Heightened Activity Will Continue in Some Areas," *World Oil* 225, no. 2 (February 2004): 63–65, 69.
3. For an example: Williams, reference 1.
4. For more on drilling in tectonically active areas: Addis T, Last N, Boulter D, Roca-Ramisa L and Plumb D: "The Quest for Borehole Stability in the Cusiana Field, Colombia," *Oilfield Review* 5, no. 2/3 (April/July 1993): 33–43.
5. For more on the KTB project: Bram K, Draxler J, Hirschmann G, Zoth G, Hiron S and Kühr M: "The KTB Borehole—Germany's Superdeep Telescope into the Earth's Crust," *Oilfield Review* 7, no. 1 (January 1995): 4–22.
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The vast majority of wells are considered straight, but to call them straight is to ignore the natural tendency of boreholes to deviate from verticality. Without special drilling procedures or technology, boreholes typically tend to penetrate bedding planes and other geological features at a right angle. Before the advent of wellbore-surveying technology, exploration and production (E&P) companies might not have realized the degree of borehole deviation and tortuosity until logging or casing-running operations became hampered by an unexpectedly complex borehole profile. In addition to natural drift, drilling practices can also create boreholes with doglegs or other irregularities in shape or direction, which also might go undetected until they impede operations.

Directional drilling and surveying technology has afforded E&P companies more control over well paths. In addition, drillers have continually upgraded drilling practices with a host of enhancements that include fine-tuning bit selection, optimizing weight on bit and improving hole cleaning. The addition of rotary steerable systems to the driller's arsenal of technologies complements many of these improvements.

Introduced within the last decade, rotary steerable drilling technology continues to advance.[1] Innovative rotary steerable systems facilitate drilling long horizontal sections with excellent directional control, drilling with bicenter bits, drilling in harsh environments and drilling in soft or unconsolidated formations. In addition to the complicated or record-breaking operations that typically make headlines, rotary steerable systems are improving seemingly ordinary vertical drilling operations.

A new rotary steerable system for vertical drilling is capable of preventing boreholes from deviating from vertical and can also return inclined boreholes to verticality. Available for a wide variety of hole sizes, this system rotates continuously to provide superior hole quality and hole cleaning, which minimize the risk of mechanical sticking and effect a higher rate of penetration (ROP).

In this article, we introduce the PowerV vertical drilling system and demonstrate its application in Italy. We begin by exploring the impetus for drilling vertically.

Why Drill Straight?

Simple, vertical boreholes account for most of the approximately 70,000 wells drilled each year.[2] E&P companies typically strive to minimize the cost of these wells and often make no special effort to keep them straight. However, certain situations dictate that companies drill vertical wells that are very straight and smooth.

An E&P company might prefer to drill a smooth borehole that penetrates a reservoir vertically.[3] A smooth vertical hole facilitates running larger casing with minimal clearance, and affords the possibility of using an extra string of casing at some later stage in well-construction operations. A borehole that drifts

PowerV Tool Specifications				
PowerV tool	475	675	825	900/1,100
Maximum rotating speed (rpm)	250	220	220	200
Maximum operating temp. (°F)	257/302*	257/302*	257/302*	257/302*
Maximum weight on bit (lbf x 1,000)	50	65	65	65
Maximum torque at bit (ft-lbf x 1,000)	4	16	16	48
Flow range (gal/min)	220 to 400	320 to 650	480 to 1,900	480 to 1,900
Bit pressure drop required (psi)	600 to 800	600 to 800	600 to 800	600 to 800
Maximum operating pressure (psi)	20,000	20,000	20,000	20,000
Vertical-control system	automatic	automatic	automatic	automatic
Available hole sizes (in.)	5 3/4 to 6 1/2	8 1/2 to 9 7/8	10 5/8	12 1/4 to 22
*High-temperature version available				

^ PowerV vertical drilling system. Based on the proven PowerDrive rotary steerable system, this simple, rugged tool can be configured to be as short as 12 ft [4 m] and to drill holes from 5¾ to 22 in. in diameter. The standard model operates in temperatures up to 257°F [125°C]; the high-temperature model operates in temperatures up to 302°F [150°C]. All models operate at hydrostatic pressures up to 20,000 psi [138 MPa].

away from and back into verticality can eliminate this option. An even greater benefit is that high-quality vertical drilling presents the opportunity to minimize borehole size at the outset. A smaller hole typically is faster to drill and entails lower costs for cuttings disposal, tubulars and cement.

Many operators minimize the footprint of drilling operations at surface by directionally drilling several wells from one surface location to widely spaced bottomhole locations. In these operations, vertical drilling is an essential technique to avoid borehole collisions in tophole sections drilled from offshore templates and onshore drilling pads. Wells that deviate even slightly from vertical above the kickoff point jeopardize the operator's ability to use all available well slots.

In addition to surface constraints on drilling operations, subsurface conditions play a role in wellbore designs. For example, drilling to targets below faulted rocks, in steeply dipping beds or in tectonically active areas sometimes requires special effort to maintain the desired trajectory.[4] Vertical drilling technology is one option for reaching a specific target.

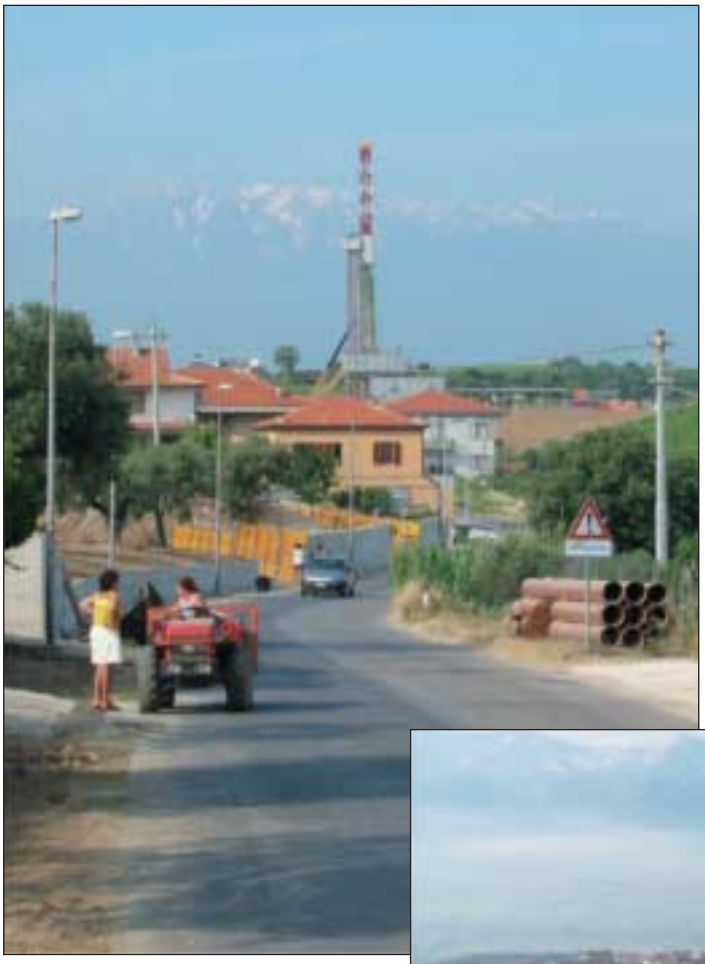
Special drilling projects also benefit from vertical drilling. For example, Kontinentales Tiefbohrprogramm der Bundesrepublik Deutschland (KTB), the German Continental Deep Drilling Program, drilled a 9,101-m [29,860-ft] vertical well to study fundamental aspects of the Earth's crust.[5] A vertical drilling system limited building angle and minimized hole size and friction.

Vertical drilling of tophole sections is also critical to the success of extended-reach drilling operations. Excessive tortuosity in the top hole causes increased torque and drag in subsequent hole sections, which can lead to wear of drillpipe and casing. Tortuosity also increases the potential for drilling problems, such as poor hole cleaning, stick/slip and inability to reach planned depth because of torque and drag. A smooth, in-gauge borehole often yields superior well logs that simplify formation evaluation. Clearly, E&P companies have many compelling reasons to drill smooth, straight holes.

In the past, simple pendulum assemblies were run to maintain low borehole inclination angles, but they offered limited effectiveness in hard or steeply dipping formations. Correction runs to bring the borehole back to vertical were costly and did nothing to prevent the problem from recurring. To address the need for straight and vertical wellbores, a rotary steerable system is now available for vertical drilling applications. This new system keeps the borehole vertical at all times and provides the additional advantage of high ROP; its continuous rotation minimizes the risk of mechanical sticking, and its lack of stationary downhole components eliminates the anchoring effect of a nonrotating part.

New Vertical Drilling Technology

The PowerV tool offers a unique set of capabilities (above left). Programmed on surface to



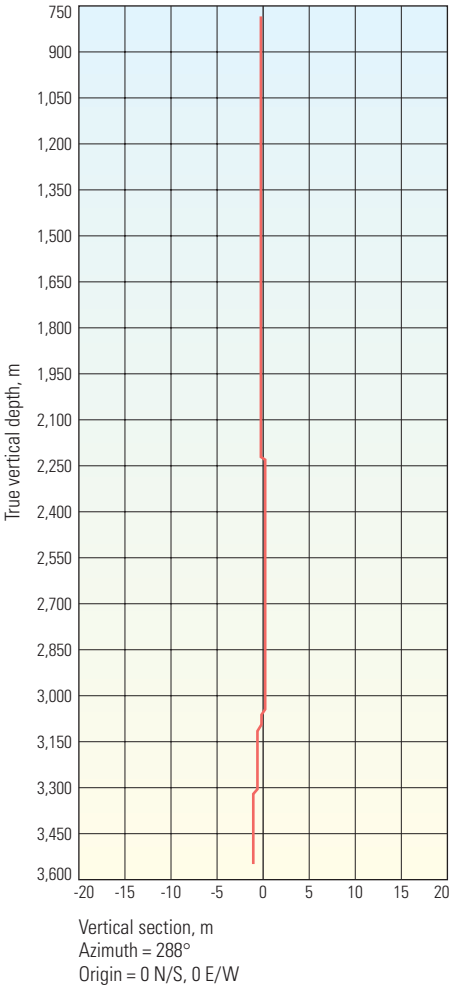
^ The Miglianico field near Pescara, Italy.

automatically seek and maintain verticality, the tool actively steers to constantly maintain verticality without any interaction from surface once deployed in the hole. Sensors in the full triaxial survey package within the PowerV tool determine whether inclination is changing, along what azimuth and by how much. If changes have occurred, the tool automatically determines the direction necessary to steer back to a vertical orientation by using pads that actively push against the high side of the hole. This automation means that drilling with the PowerV system requires no adjustment at the wellsite.

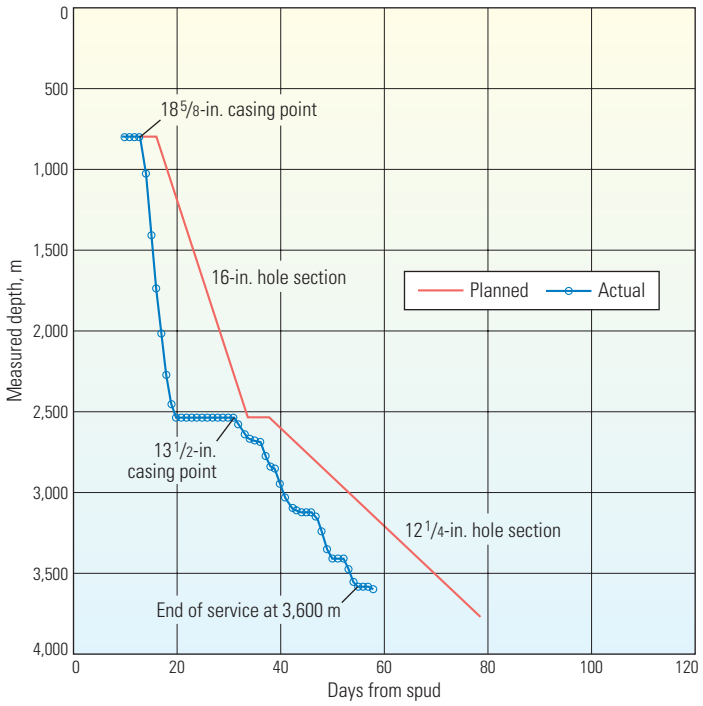
This rotary steerable system does not depend on a measurement-while-drilling (MWD) system to operate. However, a simple inclination-only MWD device enables real-time inclination measurements.

Rotary speed can be adjusted to optimize equivalent circulating density (ECD) and annular hole cleaning. Full rotation to aid hole cleaning and manage ECD is important even in vertical holes and particularly in land operations, where the rig might be pump- or pressure-constrained. ECD and hole cleaning are also important in deepwater wells with critical mud-weight windows, and in stressed or fractured rocks and sensitive formations.[6]

Other advantages of the robust PowerV system include precise well placement, high-quality boreholes, high ROPs, and effective hole cleaning. In addition to enhanced drilling results, deployment of this system requires a smaller



^ Using advanced vertical drilling technology to maintain hole angle at an average of 0.18° while drilling 2,796 m [9,173 ft] in 16-in. and 12¼-in. sections. By drilling the 16-in. section in one run and the 12¼-in. section in eight runs with the PowerV tool, Eni obtained ROPs that were more than 20% higher in the Miglianico 2 well than in offset wells.



^ Faster drilling with PowerV system. Eni drilled the Miglianico 2 well 15 days ahead of plan.

wellsite crew, which reduces cost and minimizes crowding at compact drilling locations.

Vertical Drilling in Difficult Formations

In Pescara, central Italy, Eni is drilling development wells in the Miglianico oil field (previous page). The carbonate reservoir sits beneath tough, plastic claystones that make drilling large-diameter boreholes difficult. In particular, claystone cuttings interfere with optimizing hydraulics.

Eni selected the PowerV tool to drill the Miglianico 2 well. In particular, the company wanted to improve efficiency, hole cleaning and wellbore quality. The SlimPulse third-generation slim MWD tool confirmed verticality in real time. To improve drilling efficiency and increase ROP, the system was deployed with a PowerPak steerable motor integrated in the bottomhole assembly.

The PowerV tool drilled the 16-in. borehole section, a length of 1,736 m [5,696 ft], in one run (above left). The rate of penetration (ROP) was 21% higher than the average ROP of nearby wells. The 12¼-in. section, drilled in eight runs, was 1,060 m [3,478 ft] long, and the ROP was 24% higher than that of offset wells. Both sections were drilled with no tool failures and a savings of 15 days compared with the drilling plan (above right).

Encouraged by the success of the Miglianico 2 drilling, Eni used a specially built, 22-in. PowerV tool to drill the tophole section of the Monte Enoc 5 well in the Grumento Nova field of southern Italy. The PowerV system drilled troublesome clay-rich alluvium at surface and hard limestones just below the point at which conductor casing is set, and it did so at higher rates of penetration than a conventional bottomhole assembly.

A Cost-Effective Solution to the Vertical Challenge

Although vertical drilling may seem relatively simple, it can present challenges similar to directional drilling, and it is required in some of the most expensive operating arenas, such as subsalt developments in deep water. A rotary steerable system that excels at drilling vertically offers new possibilities to reduce well-construction costs for E&P companies by eliminating time-consuming correction runs to straighten wandering wellbores, by increasing ROP, or both.

Like other rotary steerable systems developed by Schlumberger, continuous rotation of the PowerV system with the drillstring offers the advantages of minimizing risk and improving borehole quality. —GMG

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