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SPECIAL FOCUS: ADVANCES IN DRILLING

The evolution of one run intervals

The drilling challenge remains the same: Drill faster and more efficiently to reduce drilling time. New technologies are being introduced to evolve to one run intervals, which reduces drilling time.

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Today, many operators face a similar drilling challenge: To optimize the bottomhole assembly (BHA), to drill multiple wellbore sections in a single run. Significant efficiencies are gained by combining sections, and it is not uncommon for the vertical, curve and lateral to all be drilled using a single BHA.

The industry continues to strive for higher build rates in the curve section and overall reduced drilling time, to maximize asset value. The higher build rates require larger force output from the rotary steerable system (RSS), a more steerable bit, and a directional-friendly BHA. To reduce drilling time, the assembly must also be robust and stable at high weight on bit (WOB) and torque on bit (TOB), to help prevent damaging vibration that can ultimately lead to an unplanned trip.

Halliburton continues to improve tool reliability and capabilities to achieve these goals with the iCruise® X intelligent rotary steerable system (RSS) and the HyperSteer™ directional drill bit line. Combined, these technologies increase the success rate of completing even the most challenging wellbores in a single BHA.

CASE STUDY

An operator in North America drilling a 6.75-in. hole required an RSS assembly to complete a curve and drill the lateral in a single BHA at a high rate of penetration (ROP). To meet the directional plan, the assembly needed to yield between 8° and 10° dogleg per 100 ft while still being able to achieve instantaneous ROP in the lateral, upward of 350 ft/hr. To meet this challenge, a local, application-specific engineering team was employed. They designed a solution that could help the operator reliably and repeatedly achieve these objectives.

During the planning stage, a traditional 6.75-in. bit with six blades and 13-mm cutters was simulated on the iCruise X intelligent RSS assembly to determine steerability and maximum dogleg severity (DLS) capability. The simulation determined that, using a traditional drill bit, a flex joint was necessary to achieve the DLS of 10°/100 ft required by the application. While this bit with a flex assembly could drill the curve section, the flex assembly could potentially limit the maximum weight on bit and ROP in the lateral.

With a planned lateral section of approximately 10,000 ft, limits to the ROP had considerable effects on the overall well construction time and costs. The Halliburton team designed a customized drill bit to deliver the DLS requirements of the curve without a flex assembly to maximize ROP in the lateral that followed.

A new bit design featuring HyperSteer drill bit technology was designed for the application. The design incorporated learnings from our company's Cerebro® in-bit sensor and used Juggernaut® PDC cutter technology. HyperSteer drill bit technology reduced makeup length by 2.1 in., compared to the traditional bit design, while simultaneously improving stability with a slightly increased gauge length. When our firm ran the new HyperSteer drill bit with the iCruise X RSS using simulation software, the maximum DLS increased by 2°/100 ft, allowing for the flex joint assembly to be removed while still landing the curve on target per the directional plan.

The simulated capabilities of the iCruise X RSS with HyperSteer drill bit technology were validated during the

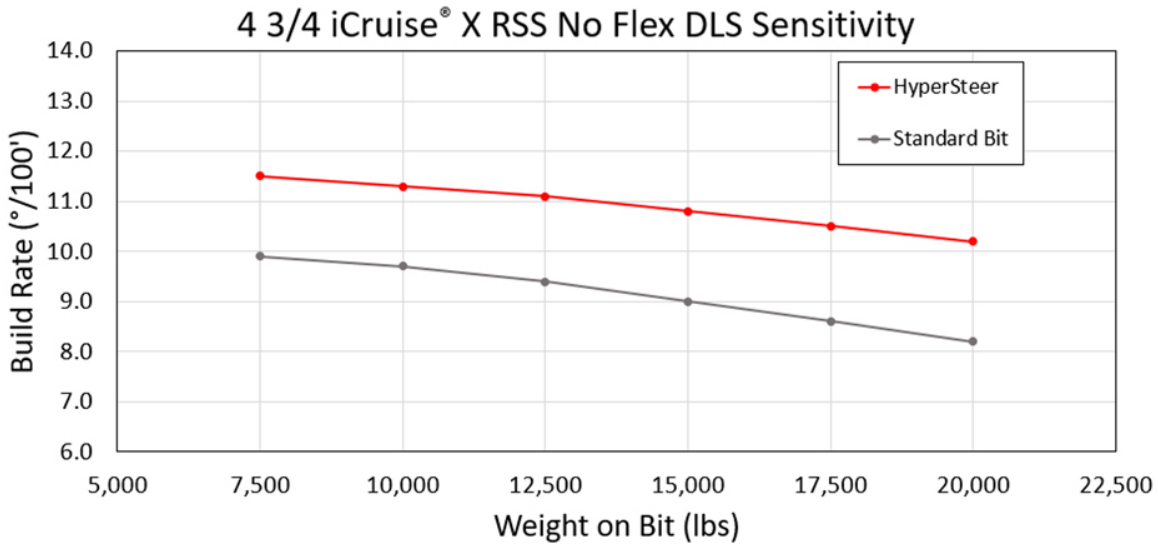

Fig. 1. HyperSteer bit technology achieving higher doglegs without a flex assembly with the iCruise X intelligent rotary steerable system.

first field run by achieving doglegs of 10°/100 ft in the curve without a flex assembly, **Fig. 1.** Removing the flex joint also meant a stiffer BHA in the lateral and reduced vibration, with instantaneous ROP exceeding 350 ft/hr. Additionally, the shorter and stiffer RSS allowed the MWD survey and LWD sensor measurement points to be closer to the bit, permitting more precise control and more accurate wellbore placement.

The operator continues to use the assembly. Since the drilling campaign began, the combination of the iCruise X RSS and the HyperSteer drill bit technology has been used to complete 10 curves without a flex assembly, with multiple runs reaching TD with a single BHA. The stiffer assembly, robust iCruise X RSS design, and HyperSteer drill bit have eliminated trips in the lateral to address damaging vibration, increasing the single BHA to TD success rate.

INNOVATIVE TECHNOLOGIES

In some areas, operators are forced to drill through tough interbedded formations to reach hydrocarbons, often requiring higher mud weight and more extreme drilling parameters. Traditional rotary steerable systems operating in these extreme conditions require the limiting of drilling parameters and can experience a higher failure rate. In other applications, operators plan one well to drill longer reservoir sections, either via multilaterals or extended-reach drilling. These applications require an RSS to remain in hole for hundreds of hours, precisely steering the well through the reservoir.

The iCruise X intelligent RSS is targeted at longer, harsher applications to deliver more precise well placement and reduced well time. Halliburton built the new tool around a robust mechanical design and the latest metallurgy, with higher-strength materials and new connections for optimal performance in geologically complex wells, high-temperature environments, or in applications with variable drilling fluid conditions.

This system includes a new steering section, whose design uses field data gathered during the application of the first iCruise intelligent RSS. The new steering head design optimizes flow paths to minimize the impact of high-frequency torsional oscillations. The sealing system is now equipped with advanced metal-to-metal seals to withstand higher internal pressure, deliver more force at the same pressure, and increase tolerance to varying drilling fluid parameters. The extra force available for steering delivers curves faster and provides a stiffer assembly for straight well sections.

The iCruise X RSS is designed around a platform that includes advanced electronics, multiple sensors and survey packages, sophisticated algorithms, and high-speed processors, to support the precise control of the tool face and drilling automation. The iCruise X RSS features two different automation methodologies. When drilling curve sections, the LOGIX® autonomous drilling platform uses surface and downhole controls to automatically transition between curves and laterals in real time to provide operators with faster, more consistent, and repeatable drilling performance. The surface-based platform delivers automated advisory steering commands to the

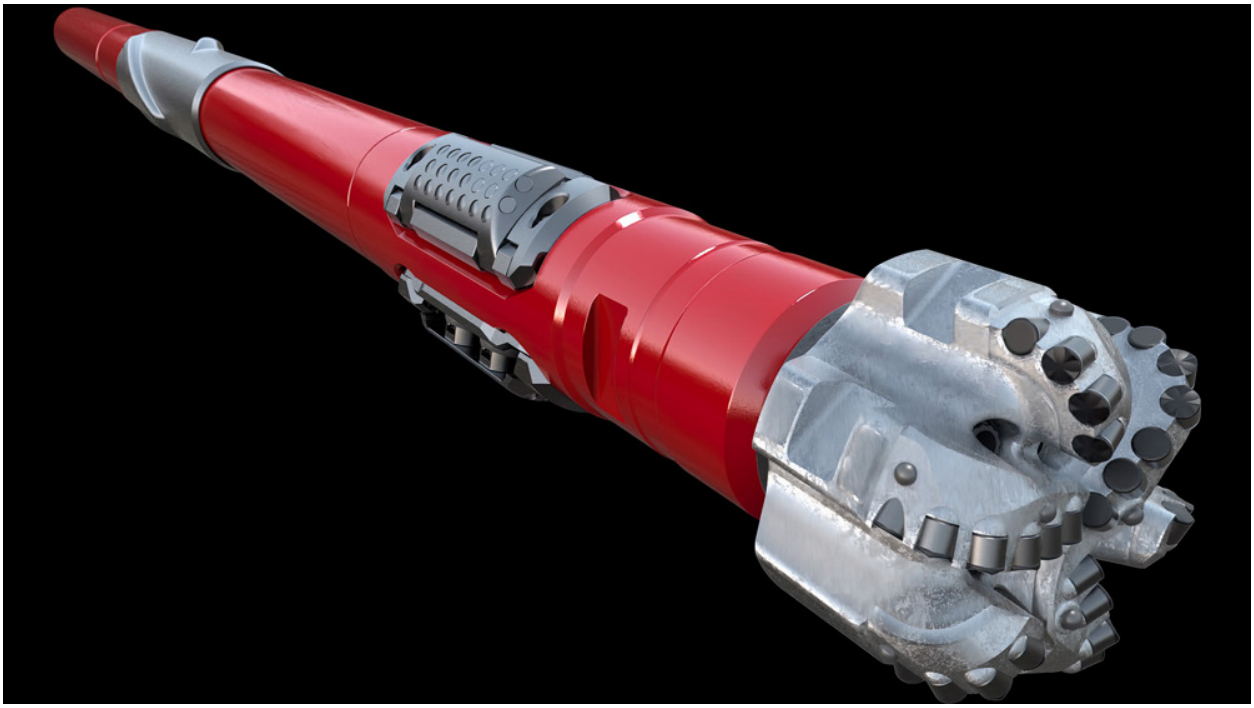

Fig. 2. The HyperSteer drill bit technology with the iCruise X intelligent rotary steerable system.

iCruise X RSS to precisely follow the well plan without human intervention.

When drilling vertical, tangent, or lateral sections, the iCruise X RSS uses the CruiseControl® system. This is an autonomous system that keeps the RSS drilling straight, by monitoring minute deflections from the well path and automatically correcting without requiring any operator input from the surface, reducing well time while also minimizing tortuosity in these straight sections.

HyperSteer drill bits are designed for applications that require minimum makeup length for maximum steerability. Using the DatCI™ design at the customer interface process, our company's ADE™ design evaluation specialists can customize makeup length for high-build-rate applications.

Drilling a curve and lateral in one run with an RSS requires a highly steerable bit to meet dogleg severity requirements. Simultaneously, the bit must be stable at higher rates of penetration (ROP) to help minimize harmful shock and vibration when drilling the lateral. HyperSteer drill bits address both challenges by reducing makeup length and maintaining sufficient gauge length. Reduced makeup length allows the RSS to transfer more side force to the drill bit for increased side cutting and higher build rates in the curve, while the gauge length provides stability in the lateral, particularly when ROP is increased.

HyperSteer drill bits are designed to minimize makeup length without eliminating the gauge pads. Historically, one of the primary methods for reducing makeup length was shortening and, in some cases, eliminating the gauge pads. However, while shortening the gauge length can increase build rate capabilities, it trades off stability and ultimately durability. HyperSteer drill bits address these issues by moving the breaker slot into the gauge pad and reducing length by eliminating the shank. Halliburton Drill Bits and Services have reduced bit length up to 44% over a standard design while maintaining the same gauge length.

When dogleg requirements of a curve and lateral RSS application exceed 8°/100 ft, most assemblies must incorporate a flex joint. Flex joints allow the assembly to build at higher rates and meet directional requirements. However, the flex joint poses challenges when drilling in the lateral at higher WOB and ROP. Flex joints reduce BHA stiffness and increase the propensity for damaging shock and vibration.

By combining the increased pad force from the iCruise X RSS and the reduced makeup length from the HyperSteer drill bit, our company meets and exceeds dogleg requirements. In several cases, the combination of the iCruise X and HyperSteer drill bits has allowed the flex assembly to be removed and still meet the directional plan. By removing the flex joint, additional WOB and thus ROP can be achieved in the lateral without inducing harmful vibration, which enables drilling a section in a single run.

DRILLING INTO THE FUTURE

One way the industry strives toward increased efficiency and safety is through a reduction in the number of BHAs required to drill a wellbore. Revolutionary solutions are required to meet directional drilling challenges and deliver successfully. Halliburton is committed to investments in innovative technologies that address these challenges. The combination of the iCruise X RSS, HyperSteer bit technologies, with automation, such as the LOGIX® autonomous drilling platform, are at the forefront of an industry transformation to complete multiple wellbore sections in a single run, reducing cost and minimizing safety risks associated with BHA trips. Together, these technologies can alter the underlying economics of drilling, maximizing asset value to customers. **WO**

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