**CHALLENGE**

Drill 7 7/8-in curve and lateral sections of a Marcellus Shale well in one run, with good directional control and high ROP. Reduce NPT caused by motor and MWD failures.

**SOLUTION**

Run innovative, application-specific Spear* shale-optimized steel-body PDC drill bit.

**RESULT**

Saved 2.7 d of rig time and USD 175,000 by drilling both intervals in one run. Eliminated downhole equipment failure by reducing vibration.

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**Shale bit suitable for both curve and lateral sections required**

EOG Resources wanted to reduce the number of days and trips required to drill the 7 7/8-in curve and lateral sections of wells in the Marcellus Shale, Pennsylvania, by efficiently drilling both sections in one run. Previous bit designs were aimed primarily at either the curve or the lateral, necessitating a trip to change out the bit and adjust the motor bend angle at the end of the curve section. Bits that target the curve section have strong build tendencies and predictable toolface control, but often deliver low ROP in the lateral. Conversely, bits for the lateral section are built for aggressive, fast ROP, but increase the risk of improper build rates in the curve section. The use of two bits and extra trips meant higher costs. In addition, EOG wanted to reduce the NPT caused by motor and MWD failures.

Engineers needed to design a PDC bit that could be run on a positive displacement motor (PDM) with a lower bend angle, allowing rotation and a high ROP in the lateral. At the same time, the bit had to be capable of achieving the desired build rates (8° to 16°/100 ft) and ensuring good directional control in the curve section. Long lateral drilling in shale plays presents additional challenges such as cuttings accumulation at the bottom of the well, which impedes access to fresh rock and results in low ROP, packed blades, nozzle plugging, and stick/slip.

**Application-specific steel-body PDC bit designed**

A Smith Bits team consisting of field engineers, design engineers, and hydraulics experts was assembled to design and manufacture a bit that would achieve the primary goal of drilling the entire 7 7/8-in production interval in one run. The team had access to several proprietary modeling and database tools, including:

- IDEAS* integrated drillbit design platform
- DBOS* drillbit optimization system for rock strength analysis
- YieldPoint RT* drilling hydraulics and hole cleaning simulation program
- DRS* drilling record system, a collection of nearly 3 million bit runs.

EOG provided valuable BHA data, mud properties, and offset run information for focusing the design. Close cooperation between the various groups resulted in new PDC bit technology, the Spear 7 7/8-in SDi513 drill bit, which provides a good balance between high build rates, superior directional control, and fast ROP, significantly reducing operating costs.

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**Innovative Spear 7 7/8-in SDi513 steel-body PDC drill bit, specifically designed for Marcellus horizontal shale drilling**
CASE STUDY: Spear bit delivers steerability and high ROP, Marcellus Shale, Pennsylvania

USD 175,000 saved on a single well
Spear 7 7/8-in SDi513 shale-optimized steel-body PDC drill bit, together with a fixed bend steerable motor, drilled the 6,241 ft of curve and horizontal intervals in one run, eliminating costly trips for PDM adjustments and bit changes after landing the curve. Reduced vibration also solved the problem of PDM and MWD failures. The bullet-shaped steel body and various other design features effectively combat buildup of cuttings in front of the bit and the resulting adverse effects.

Based on comparisons with the offset average, total drilling time was reduced by 2.7 d. The improved performance saved EOG USD 175,000 in rig-time and bit costs, and shortened time to production, allowing more wells to be drilled in a given period.

Borehole trajectory

The new 7 7/8-in SDi513 bits have been run on steerable PDMs with the following operating parameters:

- PDM speeds from 0.28 to 0.66 rev/galUS
- typical PDM configuration
  - 6½ in, 4.5 lobe, 7.5 stage PDM (0.66 rev/galUS)
  - 6½ in, 7.8 lobe, 4.8 stage PDM (0.66 rev/galUS)
- motor bend angles from 1.5° to 2.6°
- typical BHA: bit, PDM, universal bottom hole orientation (UBHO) sub, nonmagnetic drill collar, and nonmagnetic flex joint
- flow rates ranging from 350 to 500 galUS/min
- weight on bit (WOB) ranging from 2,000 to 20,000 lbf
- mud weights in the curve from 9.7 to 10.3 lbm/galUS
- mud weights in the lateral from 10.3 to 11.3 lbm/galUS