Comprehensive Well Planning Pays Off

By Jeffery Boggs, Joshua Hinton, Glenn Boyd and Peter Rottler

CANNONSBURG, PA.—In late March, CNX Gas Corporation completed its fifth and sixth Marcellus Shale producers in Greene County, Pa., an area known as the fairway of the state’s Marcellus play.

Wells GH10CV and GH10ACV began flowing to the sales meter with an initial production rate of 2 millions cubic feet a day, with shut-in casing pressures above 3,000 psi. Over the next 24 hours, the wells’ production ramped up to peak rates of 3.9 MMcf/d and 3.7 MMcf/d, respectively.

Subsequent wells—GH11CV and GH11ACV—were completed using the zipper fracture technique, with adjacent stages treated sequentially without pressure bleed off, resulting in improved well performance. Fracture operations alternate between placing treatment stages in two adjacent or parallel well bores, so that a frac job is pumped in the first stage on well A, followed by the first stage on well B, and then back to well A for the second stage treatment.

Another well, GH10BCV, was successfully drilled with rotary steerable technology—the first Marcellus well to use a rotary steerable system.

In July, J. Brett Harvey, chairman and chief executive officer of CNX Gas, said the company was continuing to apply innovative techniques to its shale program. He expressed his belief that CNX Gas was achieving results as good as any of its competitors, especially considering that its first horizontal Marcellus Shale well only came on line in October 2008. As the company’s drilling program has matured, Harvey noted, CNX Gas lowered development costs while increasing operating efficiencies.

What remains to be told, to quote the late Paul Harvey, is the rest of the story.

Total Commitment

By making a total commitment to the field development project, CNX Gas ensured that each phase of the well construction, from spudding to completion, would be complementary. This means that the project would start with an overall comprehensive design plan, which ensured that techniques used and information gathered during the early stages would complement later stages.

All too often, for example, a well is drilled using a drilling fluid that may benefit penetration rate, but that causes formation damage, ultimately impairing production or driving up completion costs. By taking a holistic approach, each product or service used in well construction is considered in light of its effect on the final solution, so rigorous cost/benefit analyses can be made to optimize decision-making.

Although a detailed plan is a good idea, following it blindly is not. Accordingly, the plan is a dynamic variable that benefits from learnings acquired as the job progresses. The best way to keep track of all the information that streams in during well construction is to first develop a dynamic reservoir model from all the relevant information available before drilling begins.

This can include drilling reports, production records, logs and cores from offset wells, as well as seismic data and geologic maps. The resulting model serves as a base case, which allows the operator to manage by exception. As long as observations are within established norms for the area, no red flags are raised, but if a parameter starts to drift off-trend, the engineers are alerted, usually in time to take straightforward remedial action.

When planning the GH10BCV well, CNX Gas was tasked with drilling a true 3-D “turn-a-zontal” well path. The more complicated drilling plan required new ideas and innovation.

Working with Smith Technologies and Schlumberger, drilling engineers selected a bottom-hole assembly based on a model that addressed the majority of issues expected during the drilling phase. Smith used its proprietary drilling dynamics simulation and design software to help drilling engineers in bit selection. The program recommended the Mi616 polycrystalline diamond compact bit for the well’s critical lateral sections.

Taking into account the lithology and hardness of the formations being drilled, it appeared that optimum bit performance would be obtained by drilling at high revolutions per minute. High-speed drilling can reduce destructive bit vibration, extending bit life and increasing penetration rate.

Once the optimal bit design for the formations had been selected, the next step was selecting a rotary steerable system. The Schlumberger system chosen provides additional torque capacity that allows higher weight on bit for increased penetration rates and more productive drilling. To obtain the desired rpm without rotating the entire drill string at high speed, the
Schlumberger system employs a powerful straight mud motor, in this case a 7.0-inch steerable motor designed for drilling with aggressive bits and maximum rate of penetration. With the motor located just above the RSS in the BHA, the bit can be rotated at the desired rpm without turning the entire string at that speed.

The well construction project for the GH10BCV well represented the first application of rotary steering in a Marcellus horizontal well. Most Marcellus directional wells had been drilled using oriented-mud motors, with as much as 45 percent of the drilling time spent in sliding mode. After switching to RSS, CNX Gas was able to drill its laterals one full day faster than the nearest offset well drilled with oriented-mud motors.

Not only was lateral ROP increased by 57 percent, but longer lateral lengths were achieved because of reduced well bore tortuosity and drill string torque. Better well bore quality facilitated running casing to total depth. By pushing the boundaries, CNX Gas challenged Marcellus Shale laterals by allowing for faster drilling and increased lateral length. This saved both time and money.

Integrated Formation Evaluation

CNX Gas used a gamma ray to log the open hole of the vertical and horizontal wells GH11CV and GH11ACV. However, a nearby pilot well was logged for correlation and direction using an integrated open hole logging tool, which is twice as fast as triple-combo. This increased efficiency with higher logging speeds, reduced set-up and calibration time, and faster turnaround on well site processing.

Additionally, CNX Gas selected an elemental capture spectroscopy sonde that measures relative elemental yields based on neutron-induced capture gamma ray spectroscopy. An acoustic scanning platform also was used to provide 3-D rock properties near the well bore and better behind-casing measurements. Finally, a formation imaging tool was selected to provide a qualitative image of bore hole formation resistivity.

Both wells were drilled and cased before the completion phase was begun. By batching the completion, several efficiencies were realized, as well as zipper fracture, a new complementary hydraulic fracturing technique.

Planning for the completion phase began during the drilling phase. Logs obtained during drilling were analyzed to help select optimum points for hydraulic fracture initiation. Rock-mechanics parameters obtained from the reservoir model and updated with drilling and log data helped engineers select the best perforating gun systems to complement the hydraulic fracturing stimulation program.

Many operators believe that if one plans to fracture a formation, any perforation hole will do, but this is false economy. There is clear proof that a well-engineered, high-quality perforation benefits the subsequent stimulation. Factors include hole size and quality, a hole orientation that coincides with the direction of the maximum formation stress plane, and clean, slug-free perforation tunnels. These qualities are obtained by running engineered gun systems designed to deliver the desired performance.

In the CNX Gas wells, a pump-down perforation system was recommended. Fracture guns were shot based on optimizing shot density, phasing, hole size and penetration.

Each gun array was loaded with 3106 Power Frac™ charges. Guns were equipped with surface addressable switches so multiple perforation clusters could be strategically located and fired for each stage of the subsequent fracture treatment.

Attached to the bottom of each gun array was a composite bridge plug and setting tool to provide stage isolation. The sequence went: pump the array into position and set the bridge plug; shear off the bridge plug and pull the guns back to the first perforation depth; fire the lowermost gun and pull up to the next depth; fire the next gun, and so on, until all the first-stage clusters have been shot. Finally, pull the guns out of the hole and start the stimulation treatment.

Zipper Fractures

The innovative zipper-fracture technique provides benefits in batch completions, enabling the perforating and fracture teams to alternate between two wells, working around the clock until the job is completed. After treatment, the first well is left pressured up, while the fracture team moves to the second well. This provides a “stress barrier” around the first well that effectively prevents the fractures from the second well intersecting those from the first.

The zipper-frac procedure was pioneered in the Arkoma Basin, and has proven to be an effective and efficient way to complete multistage production zones for maximum post-treatment performance. In the CNX Gas case, treatment of both wells was completed in 30 hours, compared with a 24-hour time frame required to complete a single well previously.

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This zipper fracture was the first of its kind to be accomplished in this record time frame.

Production from both wells exceeded that of offset wells completed conventionally.

The final chapter in this story remains to be seen. Cost savings during well construction are always welcome, but it is long-term improved production that pays the biggest benefits. By their instantaneous shut-in pressures and peak production rates during their 24-hour flow tests, the CNX Gas wells look promising. Time will tell when sustained production figures are available.

However, by using a total solution approach, with engineered complementary well construction and completion techniques, the company has set itself up for a high likelihood of economic success.