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Best Practices Establish Consistency, Improve Performance

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IRVING, TX.–The first natural gas well in the Eagle Ford Shale was drilled in 2008 in LaSalle County in South Texas. There were 67 producing gas and 40 producing oil wells in the play by the end of 2009, according to statistics provided by the Texas Railroad Commission. That number had grown to 875 gas wells and 1,262 oil wells by the end of 2012, producing 950 million cubic feet of gas and 352,000 barrels of oil a day (up 275 percent from 128,000 bbl/d of oil production at the end of 2011).

"It has been an incredible play," says J.D. Hall, vice president, South Texas operations, for Pioneer Natural Resources. "I have done big projects before, but none of us were prepared for the pace and magnitude of the Eagle Ford. We are going as fast as humanly possible."

Pioneer has been operating in the Eagle Ford since the very start, building its position through an asset base in the Cretaceous Edwards Trend, which is found directly below the Eagle Ford zone. In 2006, Pioneer began experimenting with perforating and fracturing the Eagle Ford in vertical legacy Edwards wells, and spudded its first horizontal Eagle Ford exploration test–the Friedrichs No. 1 in DeWitt County, Tx.–in October 2008.

Pioneer initiated full development of its Eagle Ford program across its 310,000-acre (gross) leasehold in the region in mid-2010. Since then, the company has drilled more than 250 Eagle Ford wells. Hall reports the company plans to operate 10 rigs in the play this year to drill 134 wells under a joint venture agreement with Reliance Industries that Pioneer entered in 2010. Hall adds that most of the wells are targeting the liquids window in the play, with only minimal dry gas drilling expected in 2013.

Soaring Production

According to the company's 2012 year-end report, Pioneer increased its Eagle Ford Shale net production from 29,000 barrels of oil equivalent per day in the third quarter of 2012 to 35,000 boe/d in the fourth quarter, establishing yet another quarterly production record for Pioneer's Eagle Ford operations. Hall says the company expects its 2013 production to take another significant jump to average between 38,000 and 42,000 boe/d.

According to Hall, Pioneer's daily Eagle Ford production stream averages about 35 percent crude oil and condensate, 25 percent natural gas liquids, and 40 percent natural gas, although he explains that the wells are 100 percent gas in some areas, while in other areas, they are nearly all oil. "The Eagle Ford reservoir has well defined dry gas, wet gas and oil windows, so depending where you are in the play, production can vary from all dry gas in the south to all oil in the north," Hall observes.

Eagle Ford development activity and production growth has progressed at a stunning pace over the past three years, for Pioneer as well as other leading operators in the play. But despite its meteoric rise, the Eagle Ford is one of North America's most complex unconventional plays, with a high degree of geologic complexity and production variability even within small areas of the 20,000 square-mile play.

Repeatability and consistency are important to long-term success in any large resource play, but they are critical in the Eagle Ford, given the nature of the reservoir and well costs (Pioneer estimates its 2013 wells will cost $7 million-$8 million each to drill and complete). Consequently, Hall says Pioneer has developed a resume of "best operational practices" from its experience drilling and completing Eagle Ford wells that it is systematically applying across its entire development program.

In discussing his company's best operational practices, Hall points out that Pioneer is operating in the deepest part of the play. The Cretaceous Eagle Ford is located between the Austin Chalk and the Buda Limestone at depths ranging from 4,000 feet to more than 12,000 feet.

"The deeper part of the play may not be the same as other areas," he contends. "The Eagle Ford is not simply one big field. It has many characteristics and conditions, depending on what area you are in. Our well depths average 12,500 feet, which is pretty significant because we have to deal with much higher pressures and temperatures."

Keeping Things Consistent

One of the things Hall emphasizes in developing best practices in a new play is to keep basic design and operational procedures consistent from one well to another, rather than changing multiple parameters each time out. The idea, he says, is to perfect a standard design with proven best practices as the foundation and then expand on it over time by experimenting with new concepts and techniques to incrementally improve performance.

"It is important to try to keep things consistent to find out which wrinkles work and which ones do not," he remarks.

A case in point is the lateral lengths and numbers of frac stages in Pioneer's Eagle Ford wells. On average, the wells drilled and completed during the first three years of the company's Eagle Ford development program have had 5,200-foot laterals with between 10 and 14 frac stages per lateral. Hall says those averages may change, however, as Pioneer starts experimenting with longer laterals.

"A lot of our lateral lengths have been a result of the geometric constraints of our units. But in wells where we are not constrained by the unit geometry, we will start pushing the limit in the near future," he reveals. "For the first 100 wells, we did everything basically the same to develop a standard well design. In the past six to nine months, we have started doing offset completions and are trying longer laterals and different completion techniques."

Hall says Pioneer is still zeroing in on the ultimate answer to what the optimal fracture spacing may be, but he claims that is not the most important question.

"Well spacing is the $50 billion question," he contends. "Determining the optimal spacing will ensure that wells are close enough to not leave any reserves behind, but at the same time, far enough apart so that we are not fracturing into other wells and creating production interference and conductivity issues between offset wells. We do not have an answer yet. Well spacing is a big challenge. It takes six months to a year to get a feeling for long-term well production."

Hall adds that Pioneer believes its Eagle Ford liquids wells will have productive lives of at least 25 years.

Drilling Efficiency

While Hall says he usually assumes that bit selection should be obvious, based on past developments, he has learned that bit selection is still determined by trial and error.

"In every new play, it is trial and error," he relates, "We have settled on a good bit selection, and we are setting records everywhere. Choosing the right bit, motors and bottom-hole assembly means good, solid, improved performance."

Leslie Bauer, drilling engineering manager, says Pioneer is utilizing PDC bits for intermediate and production hole settings. She notes the company also employs short bit-to-bend motors in the bottom-hole assembly.

"Utilizing the short bit-to-bend motors is a big deal," Bauer explains. "It improves directional performance and penetration rates while drilling the production hole section."

She says Pioneer continues to reduce per-well drilling times, and is now drilling Eagle Ford wells in fewer than 30 days. "The days required to reach total depth is a key metric of the efficiency of drilling operations," Bauer points out. "We have seen significant efficiency gains in the Eagle Ford as measured by drilling times."

Pioneer initiated full development of its Eagle Ford Shale program in mid-2010 and has since drilled more than 250 Eagle Ford wells. The company plans to operate 10 rigs in the play this year and drill 134 wells, with most of those wells targeting the liquids window. Pioneer had increased its net production to 35,000 boe/d by the fourth quarter of 2012, and expects 2013 production to be up another 3,000-7,000 boe/d on average.

And that improvement is expected to continue in 2013 as Pioneer increases the use of multiple horizontal well pads in its Eagle Ford operations. According to a company operational report, the number of wells drilled from pads, as opposed to single-well locations, is expected to increase from 45 percent of its total wells drilled in 2012 to 80 percent of the wells Pioneer drills in 2013. Pad drilling further reduces well drilling times, saving $600,000 to $700,000 per well, and is expected to allow the company to drill 134 wells with 10 rigs in 2013, essentially the same number of wells it drilled in 2012 running a dozen rigs.

The ability to drill the same 134 wells with 10 rigs instead of 12 equates to averaging 13.4 wells per rig in 2013 (27.2 days per well) as opposed to 11.2 wells per rig in 2012 (32.6 days per well). In other words, pad drilling is allowing Pioneer to reduce its drilling days by 16.5 percent on each well. "Drilling the same number of wells with two fewer rigs may sound like a small thing, but it represents a substantial increase in drilling efficiencies on these wells," Hall relates.

'Data-Centric' Processes

To help identify the productive fairway and reduce uncertainty within the company's lease position, Pioneer is using a combination of log, core, seismic and microseismic data to analyze key performance variables (see "Integrating Seismic, Well Data Delineates Performance Drivers Across Eagle Ford Shale Play," *AOGR*, July 2012).

"It is easy to talk about what we do on an everyday basis, but the importance of getting subsurface interpretation and understanding what you are drilling into cannot be underestimated," Hall offers. "We are big believers in information. Getting more information reasonably and bringing it to a useful form is critical."

He points out that Pioneer had an advantage when the Eagle Ford play took off. Unlike many of the play's operators who are new to South Texas, Pioneer had been active in the region, drilling in the Edwards formation. All of its prospective Eagle Ford acreage also was held by production.

"We had drilled dozens of wells in the Edwards," Hall states. "The Eagle Ford lies directly above the Edwards. We already had a lot of logs, so all we had to do was change the horizon and we were ready to go."

That said, however, Hall notes that Pioneer's Eagle Ford drilling and completion processes are highly "data-centric," and involve analyzing all types of data to locate the best drilling sites and optimize well bore and completion designs. "We do a lot of logging early on and correlate it back to our 3-D seismic," he offers. "We do logging, reservoir modeling and integration of data to have a good understanding before we start drilling a well. We also have mud loggers on every well during drilling operations."

"One of the secrets to our success is trying new things, but doing so in measured ways to understand what works and what does not. Pioneer has done an excellent job of changing variables in a smart fashion. Everyone wants to get to the right answer quickly, but you have to take a measured approach and build on your experience to establish best practices."

J.D. HALL
Vice President, South Texas Operations
Pioneer Natural Resources

Proppant Selection

According to Hall, Pioneer originally used a ceramic proppant when it began to fracture wells in shallower areas of the Eagle Ford play, but it has since migrated to using lower-cost white sand in wells drilled in shallower areas of the field, and is expanding the use of white sand in deeper areas of the field to further define its performance limits.

In total, he reports, the company plans to pump white sand in more than 50 percent of the wells in its 2013 Eagle Ford drilling program, with the rest fractured using ceramic proppants. Why the change?

"Early on, it was all theory. We looked at original calculations, and we thought sand would crush with the reservoir pressure," Hall explains. "But as part of our learning curve, we slowly pushed white sand deeper and deeper, and discovered that crushing was not occurring."

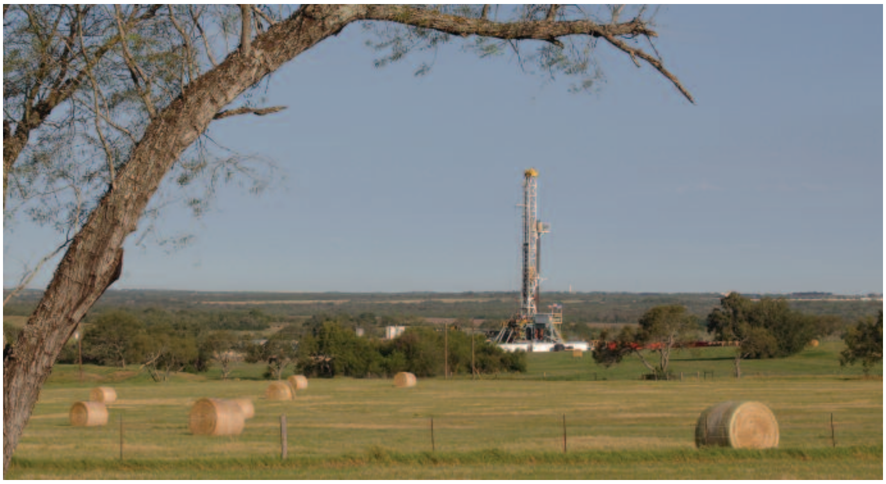
Pioneer tested 97 wells with white sand in 2011 and 2012 with favorable results. Initial well performance has been similar to direct offset wells stimulated with ceramic proppant. Because white sand is considerably less expensive than premium ceramic proppants, there is clear economic incentive, so long as long-term production and recovery rates are not negatively impacted, Hall comments.

"We saved $700,000 per well by using white sand," he states. "But the name of the game is estimated ultimate recovery. You do not want to do anything to sacrifice EUR for a little money saved upfront," he emphasizes.

Pioneer continues to monitor the performance of the wells stimulated with white sand, Hall says, but expects to see improved well performance, EURs and well economics by using the lower-cost white sand in combination with increasing average lateral lengths from 5,700 feet in 2012 to 6,200 in 2013. Although adding an additional 500 feet to the Eagle Ford laterals will add approximately $500,000 to the cost of each well, the payoff is higher production and recovery rates, he says.

Wes Hanover, a completion engineer for Pioneer, says he is using primarily 40/70- and 40/80-mesh proppants in the Eagle Ford wells he is working on. "We also have tried to go up in size to get increased conductivity within the created fractures," he says. "We have tested 30/50-mesh and are working to go up to 20/40-mesh proppant."

Hall adds that the company operates its own drilling rig and fracturing equipment



Despite the stunning pace of activity and production growth across the play over the past three years, the Eagle Ford remains one of North America's most complex unconventional geologic settings. Well costs are high, with Pioneer estimating its 2013 wells will cost $7 million-$8 million each to drill and complete. Consequently, Pioneer has developed a resume of best practices that it is systematically applying across its entire Eagle Ford development program–from geologic modeling to drilling and even midstream operations.

fleets, and even acquired an industrial sands company in April 2012 to secure a supply of high-quality brown sand for its frac operations in the Permian Basin and Barnett Shale. In the Eagle Ford, Pioneer is operating two company-owned frac fleets totaling 100,000 horsepower, and also is contracting a third-party frac fleet.

"Our vertical integration model makes it easier for us to experiment with different approaches without sacrificing drilling and completions costs," he says. "Owning the rigs, pressure pumping and well servicing equipment we need to execute our development program helps us maximize operating efficiencies in general."

Frac Fluids

Hall says Pioneer also continues to experiment with frac fluids.

"We started with slick-water fracs, but we have since migrated to cross-linked fluids," he offers. "There are thousands of theories, but until they develop a little man who can do down in the hole with a camera, it is all theories."

A cross-linked fluid system consists of water mixed with a gelling agent and a cross-linker such as boron or zirconium to increase viscosity for better proppant transport and the ability to use larger proppant sizes, he explains.

Water is also a major focus, according to Hall. He says one of the drivers in Pioneer's decision to begin making the move from slick-water fracs to hybrid cross-linked gels was to reduce the amount of water required in each frac stage.

"We recognize the concerns about water, and we want to use the least amount we can," he continues. "We are actively testing ways to reclaim and reuse frac flowback and produced water in the Eagle Ford play."

However, Hall underscores the fact that the Eagle Ford Shale is much different than many other shale and tight oil plays, in which 80 percent or more of the water pumped downhole during the hydraulic fracturing process flows back to the surface.

"We get only 10-15 percent of the pumped water back in the Eagle Ford," he observes. "It is very unique. The clays are not saturated. The rock is 'thirsty,' or at least that is the theory, so instead of coming back after fracturing, the frac fluid gets absorbed by the formation."

Infrastructure Build Out

Developing infrastructure is also critical, according to Hall.

"You can drill and complete all the wells you want, but it does not mean a thing if you do not have the infrastructure to get them on line and the production to market," he says. "Pioneer has been very aggressive with its midstream build out. We have more than 400 miles of pipeline, and our completed wells have had next to zero downtime. It is important to do the work upfront and have it ready when the wells come on."

To support its Eagle Ford Shale production growth, Pioneer has been constructing midstream infrastructure through its majority ownership of EFS Midstream LLC, an unconsolidated affiliate that provides gas and liquids gathering, treating and transportation services in the region.

Eleven central gathering plants (CGPs) are now operational as part of the company's EFS Midstream business. One additional CGP is scheduled to be on line by the end of 2013, Hall notes. The pipeline system runs through the heart of the Eagle Ford, extending 90 miles through McMullen, Atascosa, Live Oak, Bee, Karnes, DeWitt and Lavaca counties, with the gathering and processing facilities connected to major regional pipelines such as DCP, Enterprise, ETC and Copano.

Hall adds that the next challenge for Pioneer is artificial lift. In some cases, he says, Pioneer is installing pumping units to lift the liquids to the surface, but he says it also is using gas lift and plunger lift in other Eagle Ford wells to take advantage of gas drive from the reservoir to get liquids production into the sales line.

Measured Approach

Pioneer increased its Eagle Ford production from less than 2,000 boe/d in 2010 to 35,000 boe/d by the fourth quarter of 2012, and Hall says the company expects 2013 production to increase by as much as 50 percent over last year.

That kind of dramatic and sustained growth does not come by accident, Hall assures. "One of the secrets to our success is trying new things, but doing so in measured ways to understand what works and what does not," he remarks. "Pioneer has done an excellent job of changing variables in a smart fashion. Everyone wants to get to the right answer quickly, but you have to take a measured approach and build on your experience to establish best practices."

A perfect example of Pioneer's measured approach, according to Hall, is choke management.

"That is the real deal," he emphasizes. "We have seen significant production improvement since we instituted choke management. We do not open the wells all the way. We do not let the reservoir pressure deplete too quickly. That keeps reservoir performance consistent for a longer time. In wells with liquids, having a measured approach lengthens the time before we need artificial lift and it increases EUR."

Hall, who says he has been involved in deepwater projects and has worked on the Alaskan North Slope, admits he was not too excited when he learned he would be heading an onshore play in South Texas. "But the Eagle Ford has been the most challenging and rewarding development I ever have worked on," he acknowledges. "It is a complex reservoir with a lot of production variables, but when you get it right, it is a world-class reservoir. The hard part is figuring out how to get it right." ❐