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Multilateral Architectures Hold Major Potential In Resource Plays

By Doug G. Durst

HOUSTON–Multilateral technology has significant potential for improving efficiencies, lowering development costs and optimizing production and recovery rates in tight oil and shale gas plays. One of the most critical decision points in planning a multilateral project in an unconventional reservoir is determining the level of junction complexity sufficient to allow each lateral to be effectively stimulated and produced.

Although higher-level junctions provide design benefits that can be very advantageous for hydraulic fracturing operations, well construction costs tend to increase in step with junction complexity. There are pros and cons associated with each of the four Technology Advancement of Multilaterals (TAML) junction levels, but all of them can be matched with multistage completion and stimulation systems.

This includes cemented liners with plug-and-perf fracturing, cemented sleeves, open-hole fracturing using any type of fracturing sleeve and isolation devices/packers, and various types of coiled tubing completion equipment.

Some junctions have preferential fracturing and completion methods, such as when an operator wishes to have cement isolation at the junction but chooses to install an open-hole frac sleeve or a packer completion with ball-drop actuation. This would require the junction area to be stage cemented (level 4), which would add cost to the overall project because of the additional equipment and operations necessary to stage cement. The upside is a cemented isolated junction (i.e., no exposed formation issues while producing the well).

Production management also can introduce challenges for multilateral wells, where production is commingled from different formations or different parts of the same formation. Do pressure regime differences exist that require a higher-level completion to properly manage commingled production? Would any issues be resolved by simply keeping one lateral plugged while producing the other to a certain decline rate before commingling both laterals? If the junction is not isolated, the longer-term effects of production have to be taken into account since the formation will be exposed to production flow.

Separation at the heel is another consideration. The spacing of laterals, build rates and maximizing the length of the lateral to the fracture will be impacted if sufficient heel separation is not achieved by the drilling program versus the kickoff points and size of the section drilled. Multilateral well architecture also is likely to play a role in determining how artificial lift is used to produce a well. Placing a lift device to optimize production management may define the size and type of lift device, as well as help define the preferred junction type and construction.

Major Consideration

The sequence of stimulation and completion operations is a major consideration in planning multilaterals. If the plan is to drill, case, complete and frac all the laterals back-to-back and reservoir pressures are sufficient, some type of mechanical barrier must be placed in the lateral liner outside the main bore after fracturing, flowing back and cleaning out each lateral (at least for all secondary laterals and likely as well for the main borehole) to avoid having a live well scenario. The question then arises as how to retrieve or remove the barriers: drilling rig, snubbing unit/hydraulic workover unit, or a coiled tubing unit with suitable risers/lubricators.

Re-entry may be another important factor, especially if refracturing or workover requirements are possible at some later date. In a number of open-hole level 1 junctions, operators have utilized a bent sub motor or directional motor to create a sidetracked lateral out of an open-hole main borehole with no means for re-entry. Most level 2 junctions have been created by setting a bridge plug at the kickoff point, followed by setting a trip-activated whipstock to create a sidetracked lateral out of a cased/cemented main bore. As with open-hole level 1 junctions, accessing the laterals requires indexing tools or bent subs since there is no main bore positive re-entry device.

An ideal solution for new wells is to install a profile device, casing nipple or coupling in the main bore to allow repetitive depth and directional positioning for all drilling, completion, re-entry and workover operations. A profile device is an integral component to the casing/liner in new wells where full casing internal diameter is beneficial. For re-entry applications, a packer and orientation device can be used to provide the same depth and directional constant. However, the packer will create a restricted access ID to the lower wellbore should re-entry into the main bore or lower laterals be required (i.e., refracturing).

Managing surface facilities and operations between the drilling rig, workover rig and/or CT rig, and frac spread requires extensive preplanning. How these components are logistically planned and utilized impacts capital expenditures, and therefore, requires careful consideration when planning a multilateral well in an unconventional play. Additional trips and extra mobilization/demobilization costs are likely with multilateral wells, especially as junction level complexity increases. These costs will be associated with both drilling and completion.

Operational Sequence

The sequence of drilling and multistage completion operations has varied from project to project, but most have either:

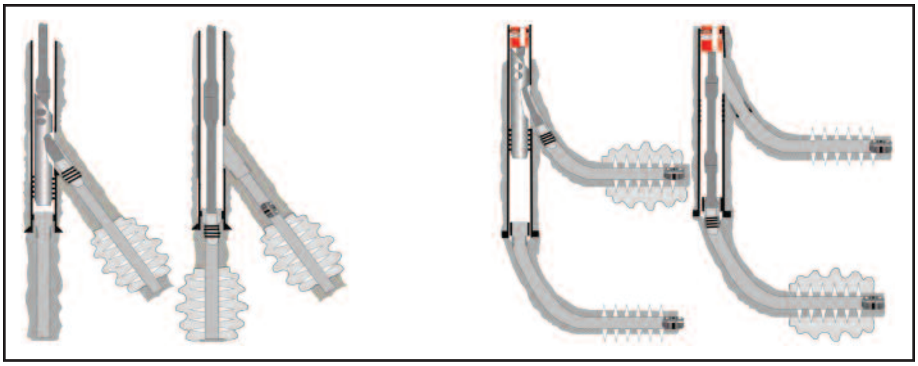
- Drilled, completed and produced one main bore lateral (until decline), and then plugged it and repeated the process for the secondary lateral; or
- Drilled both laterals, but completed and produced only one lateral until decline, and then plugged it to re-enter and complete and produce the secondary lateral.

In some cases, operators have used artificial lift to produce each individual lateral to a predetermined decline level, lifting the first lateral and then plugging and moving to the next lateral. After all laterals have been individually produced to the decline level, the plugs are often removed and commingled production from all laterals is artificially lifted to surface. In very low-pressure formations, artificial lift has been used to simultaneously produce multiple laterals from the start of production.

As shown in Figure 1, stimulating a multilateral requires either running a packer-based junction isolation tool to allow fracturing down the intermediate casing string into the lateral completion liner (isolating the junction from pressure and isolating the laterals not being stimulated), or running a long frac string

FIGURE 1

Surface Fracturing String (Left) versus Packer-Based Isolation Bottom-Hole Assembly (Right)



latched into the polished bore receptacle (no pressure can be applied to the backside of the frac string). Separate tool/string runs are necessary for each lateral leg, so a dual lateral will require either two fracturing string runs or two packer-based isolation tool runs.

Packer-based junction isolation devices first were used in the early 2000s for high-pressure multistage acid fractures in a Devonian limestone formation in West Texas. Multiple dual-lateral wells were drilled with level 2 junctions and then isolated with these devices to create a temporary, high-pressure level 5 completion architecture for selective stimulation. This approach resulted in significant cost savings and ensured the successful stimulation, testing and production of each lateral.

In the case of surface frac strings, some operators simply leave the string assembly in a lateral's stimulated wellbore and immediately put the well on production. In this case, the frac string assembly is pulled once the first lateral is produced to decline, and the second lateral is entered to complete and produce it.

Hypothetical Case Study

While level 3 and 4 multilaterals have been drilled and completed in the Granite Wash, Bakken and Mississippian Lime plays, most multilateral projects in unconventional resource plays (or conventional reservoirs where multilaterals were completed with multistage fracturing) have used level 1 or 2 junctions.

In the Permian Basin, operators have drilled multilaterals in a number of formations and completed them using multistage fracturing. The majority of the projects have been level 2 junctions with 7.0-inch main bores and 4½-inch lateral legs, and used cemented liners with plug-and-perf completions. Most of these wells had very low formation pressures, eliminating the need for mechanical barriers by using the hydrostatic head of the flowback fluids to provide temporary well control.

Based on operators' early experience using multilateral technology in the basin, a comparative economic analysis using a hypothetical Permian case study was performed for a single horizontal well versus a dual-lateral. The analysis used typical Permian drilling and completion costs, and assumed both laterals would be drilled and stimulated sequentially with a barrier installed to isolate each lateral.

All of the individual operational steps to drill, complete/stimulate and produce a dual-lateral with a level 4 junction (7.0-inch main lateral and a 4.5-inch secondary lateral) with 15 frac stages a lateral were compared with a single horizontal well with a 15-stage frac. Both cases are based on a true vertical depth of 8,000-10,000 feet, and include all expenses associated with site preparation and mobilization/skid/demobilization to drill 4,000 foot laterals and complete/stimulate the lateral sections with cemented liners and plug-and-perf tools.

The results in Table 1 indicate that the total cost of one level 4 dual-lateral will be about 20 percent less than the combined cost of two single horizontal wells, and save 15 percent in operational time. Table 2 shows the estimated operational steps to install a level 4 dual-lateral completed with multistage fracturing.

High Reliability

The goal with any drilling and completion project is to achieve 100 percent reliability of equipment and zero nonproductive time in the execution phase. Fortunately, high levels of reliability have been attained with multilateral technology through stringent design improvements, sound operational procedures and consistent job execution by well-trained onsite personnel. Even the most complex multiple-junction installations have become somewhat routine in some regions of the world.

In resource plays, in particular, reliability must be balanced with efficiency. After all, a perfect multilateral installation with zero NPT is of little value to an operator if the number of operational steps drive up costs to the point that the savings gained from multilateral architectures are lost.

TABLE 1

Cost Comparison of Level 4 Dual-Lateral Versus Two Single Horizontals

Cost	Drilling Costs	Completion Costs	Total Costs	Total Days
Single Level 4 dual-lateral well	$5,623,173	$4,637,500	$10,260,673	108
Single horizontal well	3,796,805	2,676,500	6,473,305	64
Two single horizontal wells	7,593,610	5,353,000	12,946,610	128

When properly planned, the industry's experience in applying multilateral technology in resource plays has shown benefits in terms of both improved project costs and production performance. However, as with any technology, there is a learning curve associated with reaching optimized deployment in the field.

A good approach would be to plan a multiple-well multilateral program from a single pad with the ability to easily skid a rig from well to well to create more efficient use of all necessary surface facilities. Additional efficiencies will be gained as operations progress from well to well, allowing drilling and completion personnel to gain knowledge from each subsequent well.

Technological improvements likely will be necessary in the long run to reduce pipe trips, minimize the use of the drilling rig and address the need for higher-pressure options. However, there are products, systems and services in place today to be able to make reasonable inroads on implementing a strategy to more widely use multilaterals with multistage frac operations in unconventional plays to lower development costs and achieve production and recovery rates that are equivalent to or better than single horizontal wells. ❐

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Editor's Note: The preceding article is the second of a two-part feature on applying multilateral technology in unconventional plays. Part I was published in AOGR's July issue and focused on design and operational considerations for multilateral well architectures.

TABLE 2

Estimated Operational Steps to Install Level 4 Dual-Lateral with Multistage Completion

Procedure	
Single Level 4 Dual-Lateral Well (Cemented Liner w/Plug & Perf)	
Drill and Set 13⅜ Surface Casing	**Completion Operations**
Build location, RU drilling rig	**Upper Lateral Completion/Frac (pre Washover)**
Drill/clean 17½" hole	Workover rig, mob/set up
Run 13⅜" casing to depth and cement to surface	PU work string
Drill and Set 9⅝" Casing	Polish mill run
Drill 12¼" hole/clean hole	Lay out work string
Run 9⅝" casing to depth and cement to surface	RIH frac string
Drill and Set 7" Casing w/Latch Coupling	RD workover rig
Drill 8½"–8¾" hole/clean hole	Rig up CT
Run 7" casing to depth and cement back to surface	NU frac tree
NU/Test BOPs, drill out shoe, perform FIT	Frac #1, #2, #3 pump gun/plug
Mob/Demob/Eq	Frac #4, #5, #6 pump gun/plug
Contingencies, consulting, contract	Frac #7, #8, #9 pump gun/plug
Fuel, water, power, trucking, solids removal	Frac #10, #11, #12 pump gun/plug
Drill Mainbore Lateral	Frac #13, #14, #15
Drill 6⅛" hole/clean hole	Clean out plugs
Run 4½" 11.6# casing on LH to depth, cement liner	Clean out flowback and water transfer
Set hanger and POOH w/BHA	RD CT
Mob/Demob/Eq	Set lateral barrier
Contingencies, consulting, contract	POOH frac string
Fuel, water, power, trucking, solids removal	**Mainbore Completion/Frac**
Directional	RU workover rig
Run MB Latch Orient.	PU work string
Run latch cleaning tool+gyro (3 readings)	Polish mill run
Constructing Junction in 7" Step 1	Lay down work string
RIH with milling tool and mill window	RIH frac string
Open up window with secondary whipstock/mill run	RD workover rig
Drill/Constructing Upper Lateral #2	Rig up CT
Drill second lateral	NU frac tree
RIH w/4½" 11.6# liner w/TJ PBR, cement liner	Frac #1, #2, #3 pump gun/plug
Mob/Demob/Eq	Frac #4, #5, #6 pump gun/plug
Contingencies, consulting, contract	Frac #7, #8, #9 pump gun/plug
Fuel, water, power, trucking, solids removal	Frac #10, #11, #12 pump gun/plug
Directional	Frac #13, #14, #15
Constructing Junction in 7" Step 2	Clean out plugs
PU 6⅛" bit, TIH clean out 7" to top of whipstock	Clean out flowback and water transfer
PU 3¾" bit, TIH clean out 4½" lateral	RD CT
PU washover assembly, dress junction, recover whipstock	Set MB barrier
Wellhead Attachment	POOH frac string
NU tree, clean tanks, release rig	RU CT or WL pull MB barrier & lateral barrier