

Going the Extra Mile

Using ball-activated systems to simplify stimulation of toe stages for extended reach laterals

Technological and operational improvements in the oil and gas industry have now made it possible to drill longer laterals and complete wells with higher stage counts and fracture intensity¹.

One of the challenges around completing long laterals is reaching the toe. Plug-and-perf completions are among the most extensively used solutions in the industry; however, limitations of wireline and coiled tubing (CT) used to deploy plugs and perforate casing can prevent the toe stages from being effectively stimulated.

Ball-activated systems provide a means to greatly simplify stimulation operations for the toe stages of a wellbore. By pumping balls from surface to activate, isolate and stimulate stages, the operational risks associated with CT or wireline that can lead to unplanned nonproductive time, cost overruns and lost production can be mitigated.

¹ Energy Information Association, "Trends in U.S. Oil and Natural Gas Upstream Costs"; EIA (2016) <https://www.eia.gov/analysis/studies/drilling/pdf/upstream.pdf>

CHALLENGES OF EXTENDED REACH LATERALS

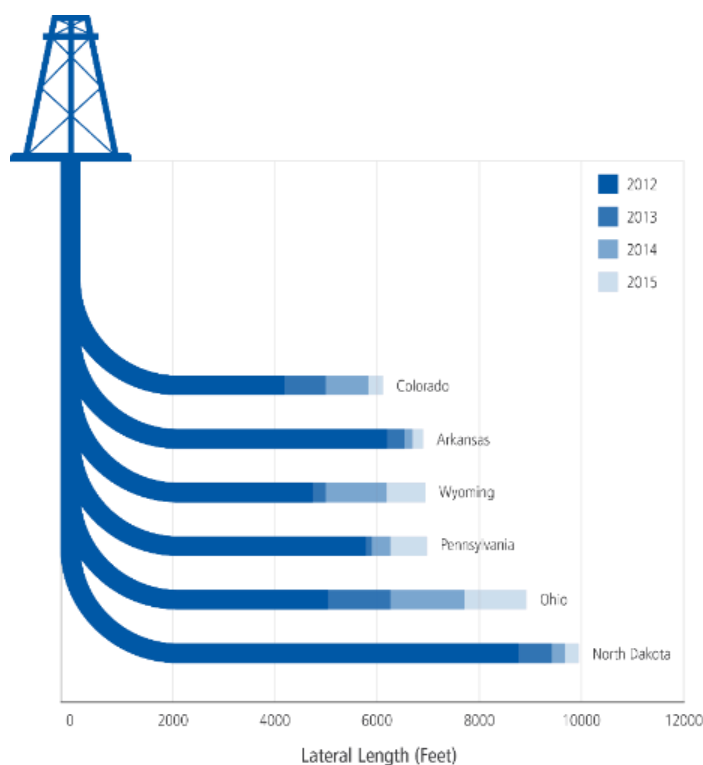
An extended reach lateral (ERL) well has a minimum 2:1 measured depth (MD) to true vertical depth (TVD) ratio². These can be shallow horizontal wells with small TVDs, or deep wells with long lateral lengths. ERL wells completed with plug-and-perf systems rely on the following intervention methods during operations:

- Wireline
- Coiled Tubing

Wireline

Wireline can be used in plug-and-perf completions to run bridge plugs and perforating guns into the wellbore to isolate and perforate sections of a reservoir. This was more straightforward in the past when most wells being drilled were vertical wells, since wireline tools depend on gravity to move downhole. Reaching the target depth for an ERL can be more difficult—gravity no longer plays a role in tool conveyance for long horizontal wellbores.

Irregularities such as doglegs, complex well trajectories and poor liner or casing conditions also increase the risk of tools getting stuck. In general, when dealing with high angle



Average lateral lengths by year for various U.S. states³

² Issa, F., Hudson, L., Jackson, A.M. "Extended Reach Horizontal Accessibility for UAE Offshore"; 2012; SPE-161751-MS <http://dx.doi.org/10.2118/161751-MS>

³ Boettiger, C. "Horizontal Productivity Gains Tapped Out?" BTU Analytics (Oct 2015) <https://btuanalytics.com/horizontal-productivity-gains-tapped-out/>

wellbores, mechanical or hydraulic means must be used to push tools further downhole⁴.

Coiled Tubing

Like wireline, CT can also be used for setting bridge plugs to establish zonal isolation in a plug-and-perf operation. After all stages in a plug-and-perf completion have been stimulated, CT can be used as a mechanical intervention tool for milling out bridge plugs prior to flowback. This is done by pumping a cleanout fluid such as water or brine into the well to circulate the debris to surface via the annulus. Despite the development of composite bridge plugs that can be milled in a continuous operation to reduce operational risk, using mechanical intervention can be costly and risky, especially for ERL wells. In ERLs and wellbores with low reservoir pressure, debris does not easily reach the surface. Furthermore, debris left behind from milling operations can result in CT getting stuck, driving up costs and delaying production⁵.

Like wireline operations, wellbore irregularities, complex well trajectories and liner or casing conditions can limit the reach capabilities of CT operations. Additional factors that affect CT reach include:

- High production rates resisting CT passage – A high flow rate of hydrocarbons back to surface can restrict CT from travelling further downhole⁶.

⁴ Billingham, M., El-Toukhy, A.M., Hashem, M.K., Hassaan, M., Sheiretov, M.L.T., Loth, M. "Conveyance—Down and Out in the Oil Field"; 2011; Oilfield Review Schlumberger https://www.slb.com/~media/Files/resources/oilfield_review/ors11/sum11/conveyance.pdf

⁵ Aviles, I., Dardis, M., Jacob, G. "Degradable Alternative to Risky Mill-Out Operations in Plug and Perf"; 2015; SPE-173695-MS <http://dx.doi.org/10.2118/173695-MS>

⁶ Al-Sharji, H.H., Ferdiansyah, E., Kumar S., Neyaei, F.A. "Challenges for Coiled Tubing in Slim Hole Horizontal Well Intervention"; 2009 SPE-122804-MS <http://dx.doi.org/10.2118/122804-MS>

- Premature lock-up – Frictional forces between the CT string and the inside of the wellbore reach a critical point such that, although more tubing may be injected into the wellbore, the end of the tool string cannot move. Without any axial movement, the tubing tends to undergo helical buckling under compression, preventing sufficient weight on bit being applied for milling operations.
- Transport regulations – Load carrying regulations set by transport authorities can limit the weight of CT available on location, which in turn limits the allowable CT length. Thinner walled strings weigh less and increases the CT length but can be more susceptible to buckling and overpull limitations⁷.

SOLUTIONS FOR EXTENDED REACH LATERALS

Friction Reducers

Friction reducers have commonly been used in ERL applications, lessening the drag forces acting between the CT and the completion liner. This includes using circulating fluid friction reducers that enable higher pump rates while lowering pipe fatigue. Metal-to-metal friction reducers enable CT to reach greater depths. Filling the tubing with nitrogen can also add buoyancy to push the CT further into a well.

Friction reducers can, however, cause formation damage, and proper care is required when selecting a friction reducer for a particular formation. The friction reduction capability of some friction reducers is also sensitive to high salinity water⁸.

⁷ Griffin, J., Nichols, C. "Optimization of Coiled Tubing Extended Reach Practices in the Bakken Region: A Case Study"; 2012; SPE-159574-MS <http://dx.doi.org/10.2118/159574-MS>

⁸ Kaufman, P., Penny, G.S., Paktinat, J. "Critical Evaluations of Additives Used in Shale Slickwater Fracs"; 2008; SPE-119900-MS <http://dx.doi.org/10.2118/119900-MS>

Workover Rigs

Workover rigs have most commonly been used for performing remedial operations, but are also being increasingly applied for drill out operations in ERLs. Workover rigs are typically smaller and more cost-effective than drilling rigs, and work with lighter weight tubing. They have the capability of reaching far out into the wellbore, but also at the expense of a slower operation and the risk of getting stuck downhole.

Wireline Tractors

Wireline tractors are self-propelled mechanical devices that were first developed in the 1990s, enabling a string to be pulled down a borehole without the need for rigs or pipe-conveyance methods. The tractor has wheels that are deployed to contact the inner wall of the casing and automatically rotate once activated, pulling the wireline assembly downhole. CT tractors developed for CT pumping operations extend the reach of the CT in both horizontal and deviated wells by several thousand feet⁹.

Despite the clear advantages that this solution provides, the use of wireline or CT units is a costly, high risk operation at extreme depths. Being primarily a cased hole service, downhole tractors are not suitable for every well and require expensive downhole equipment⁴. Wireline tractors are also typically only capable of moving downhole at a fraction of the rate of pump down operations, requiring additional time on location.

⁹ Schwanitz, B., Henriques, K. "The Development of Wireline-Tractor Technology"; 2009; SPE-0209-018-TWA <http://dx.doi.org/10.2118/0209-018-TWA>

Packers Plus Ball-Activated Completions

Packers Plus has a number of ball-activated multi-stage completion systems that can simplify toe stimulation operations. Completing the initial few stages of an ERL using a ball-activated system provides an intervention-free solution for the toe of the wellbore.

The first stage of the system is hydraulically activated to establish a line of communication between the liner and the reservoir. The remaining toe stages are then accessed by pumping down actuation balls from surface and applying hydraulic pressure to isolate each stage. These steps eliminate the need for deploying bridge plugs and perforation guns for plug-and-perf systems at the toe of the well, avoiding the inherent risks associated with wireline or CT operations.

All stages are stimulated in a single, continuous pumping operation, and the next ball is pumped with the flush of the previous stages, preventing overdisplacement of proppant into the fracture, as well as lowering time and cost.

- **Limited entry**
- **One ball activates multiple sleeves**
- **Cemented liner and open hole**

QuickFRAC®

- **Single point entry**
- **One ball activates one sleeve**
- **Cemented liner**

Diffusor®

- **Single point entry**
- **One ball activates one sleeve**
- **Open hole**

StackFRAC®



A hybrid system consisting of single point entry sleeves at the toe followed by plug-and-perf stages

CASE STUDIES

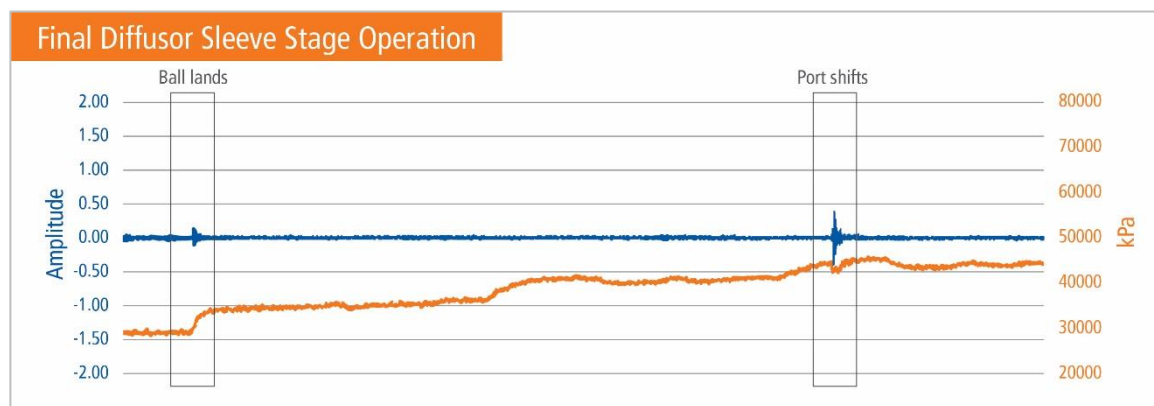
Limited Entry Treatment

An operator working in the Meramec formation in Oklahoma required an effective treatment method for proppant fracturing at the toe of a cemented plug-and-perf well with a lateral length of 4,620 ft.

A total of 3 ball-activated stages, each with 5 QuickPORT™ IV sleeves was installed at the toe. Stimulation was achieved through each of the sleeves at the designed rate followed by 20 plug-and-perf stages—the transition time between consecutive ball-activated stages was only about 15 minutes. The ePLUS® Retina™, a real-time downhole monitoring tool, was able to verify that the 15 sleeves had been opened and successfully stimulated as per the operator's treatment design.

Overcoming Breakdown Pressures

An operator working in the Alberta's Montney formation ran a high stage-count cemented hybrid system on a 4.5-in. liner, with the first 11 stages at the toe completed using 10 ball-activated Diffusor sleeves and one hydraulically-activated sleeve. The remaining stages at the heel were completed using coiled



Retina provides clear indication of ball landing on seat and port shifting in a span of approximately 16 seconds

tubing activated sleeves, with a combined lateral length of approximately 9,500 ft.

Given the high formation breakdown pressures seen at the toe, a single-point entry system proved to be effective in ensuring that the desired stimulation treatment was achieved. Pumping fluid directly through the liner versus using CT also enabled higher pump rates. All ball launch and port shift events for the sleeves were once again confirmed using the ePLUS Retina.

Maximizing Stage Density

An operator averaging 20 stages and 4,328 ft of lateral on wells in the Niobrara formation in Colorado was looking to maximize stage density with longer laterals. Based on designed rates, 50- and 51- stage systems were installed for two separate laterals, each over 10,000 ft.

A 38-stage StackFRAC® HD system was used at the toe of each well until a full bore inner-diameter sleeve was achieved.

RockSEAL® H2 packers were used in conjunction with an open hole plug-and-perf completion method at the heel. Each well was completed in less than 2 days, saving the operator significant time and cost compared to solely using plug-and-perf.

CONCLUSION

The solutions aimed at extending the reach of wireline and CT have been successful at improving the capabilities of these intervention methods; however, the higher operational risks and completion times associated with stages at the toe of a wellbore can still be substantial.

The Packers Plus line of cemented ball-activated technologies, including Diffusor for single point entry and QuickFRAC for limited-entry, provide cost- and time-effective solutions for the toe stimulation of an ERL. The StackFRAC system also provides

these same benefits for open hole wellbores. By removing the need to trip in and out of the wellbore using CT or wireline, operational risks and completion times are vastly reduced.

FURTHER RESOURCES

Packers Plus is a completion technology company that is dedicated to providing high quality solutions that work the first time. To this end, Packers Plus offers systems for a variety of applications, including cemented liner, open hole, and high pressure and high temperature applications.

Packers Plus' knowledgeable and experienced specialists have been dedicated to providing customized solutions for clients around the world over 15 years.

Explore more solutions, case studies, and news at packersplus.com