

Toughen Up

Mitigate erosion for high-volume proppant completions

New technology has steadily allowed operators to produce more from each well, all while improving operational efficiency.

Longer laterals, higher proppant loads, tighter stage spacing and higher stage counts have all contributed to increased production per lateral foot. As with many advances, however, there are tradeoffs and tipping points. The same proppant that improves production can also severely erode downhole tools, as seen in numerous field studies.

Erosion impacts all downhole systems. From limited entry plug-and-perf systems to ball-activated sliding sleeve systems and variations on each method, the result of failure is lost stages and lower production.

However, erosion can be largely mitigated with a few simple but effective solutions:

1. Tool design
2. Finding and reinforcing vulnerabilities
3. Quality control for precision and reliability

These innovations offer operators confidence in delivering aggressive treatments to maximize production, understanding that steps and tools have been taken to mitigate failure due to erosion.

EROSION CHALLENGES

No matter what completion method an operator chooses, the erosive power of high-proppant stimulations should be considered.

Single Point Entry

Sliding sleeve systems are at risk during high-proppant stimulations in different ways. The mechanical nature of these systems leaves them vulnerable to sand accumulation or erosion. Downhole keys for coiled tubing locating and shifting can be eroded to the point where neither can be done.

During stimulation, a ball and seat combination must hold back thousands of pounds of pressure to effectively isolate one fracturing stage from another with only 1/16-in. of diametric difference between the ball and seat. For conventional systems, a 1/32-in. edge is the only overlap holding back differential pressure. This interference is even smaller for modern high stage count systems.

Furthermore, the flow of fluid as it passes through a seat is briefly turbulent, which causes a slight increase in pressure. Although each seat contributes only a small amount of additional pressure, a completion string of 40 to 50 sliding sleeves can add thousands of pounds of pressure of additional friction and is a source of operational concern.

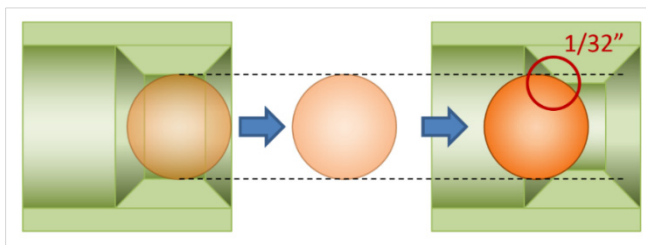


Figure 1. A ball must pass through one ball seat without resistance, but land in the next with enough interference to hold back thousands of pounds of pressure.

Limited Entry

In plug-and-perf liners, once the slurry reaches perforations, a near-instant pressure drop decrease is observed. This phenomenon is due to proppant rapidly eroding the edges of the perforations¹. Production logging also has shown that only 20-50% of the intended fracturing targets were producing at fracture-stimulated rates².

¹ Yuan, P., Zhang, H., Huang, X., Han, J., Zhou, Q., Mezzatesta, A., & Bao, J., 2017. Study of Proppant Erosion in Multistage Hydraulic Fracturing Using Computational Fluid Dynamics Modeling. Society of Petroleum Engineers. doi:10.2118/183819-MS

² Miller, C. K., Waters, G. A., & Rylander, E. I., 2011. Evaluation of Production Log Data from Horizontal Wells Drilled in Organic Shales. Society of Petroleum Engineers. doi:10.2118/144326-MS

With the first set of perforations accepting most of the fluid, other perforations in the same interval receive minimal or no treatment. This inefficient use of proppant leads to lower than expected production and lower return on investment.

On the other hand, ball-activated limited entry systems are dependent on a ball holding pressure during stimulation, while being able to pass through to the next seat in the cluster.

EROSION MITIGATION

Technological innovation has led to several solutions that strike a balance between a high-proppant stimulation and failure due to erosion.

1. Tool Design

To mitigate the cumulative friction caused by the turbulence of fluid passing through ball-activated seats, sliding sleeves have been redesigned. Using computational fluid dynamics simulation, the reshaping of the internal fluid path has reduced pressure drop (and thus fluid friction) by over 60%.

This design has been implemented throughout Packers Plus product lines and has also provided a step change in stage count limitations by providing a simple and reliable solution with smaller seat increments. It has allowed single entry point systems such as StackFRAC® HD-X to improve on the industry standard of 1/16-in. increments and move towards custom-sized increments.

80-sleeve Limited Entry Lower Completion Unseats Plug-and-Perf

An operator working in the Permian Basin had been successfully using a standard hybrid completion for wells exceeding 20,000 ft of measured depth (MD).

These wells used 5 clusters of 4 QuickPORT™ IV ball-activated sleeves at the toe, which eliminated the cost and risk associated with interventions at those depths, while gaining the advantage of eliminating entry point erosion common to limited entry stimulation. The upper stages were completed using plug-and-perf.

For a particularly long well with a 23,300 ft of MD, 20 sleeves were insufficient to cover the last 3,900 ft of the lateral. 80 QuickPORT IV sleeves were installed, grouped into 20 stages.

All 20 stages were stimulated in under 70 hours of pumping time.

The smooth operation proves the effectiveness of the TREX™ QuickPORT IV limited entry system, not only in reducing operational risk for long laterals, but in its ability to mitigate erosion and perform as a high stage count solution.

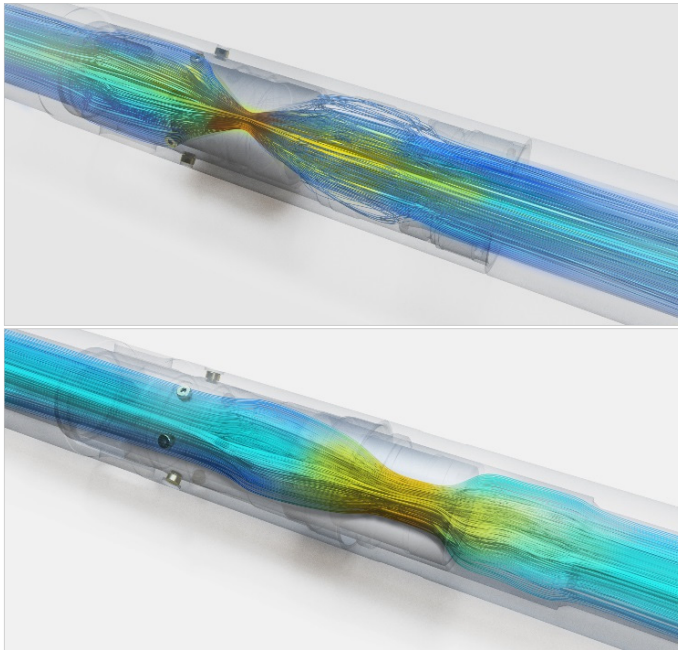


Figure 2. Mitigating fluid friction in high stage count sliding sleeve systems has become critical to their success. A reshaping of the fluid path has proven a significant improvement.

These systems are capable of up to 70 single-point entry stages (on a 4.5-in. liner), where all seats are designed to withstand 6,000 psi of differential pressure.

The TREX™ limited entry system uses a single actuation ball to pass through multiple QuickPORT IV seats. These sleeves have also been redesigned with 40% fewer moving parts than previous versions, mitigating the risk of sand fouling or erosion.

2. Finding and Reinforcing Vulnerabilities

With completions trending toward ever higher rates and proppant volumes, the 1/32-in. (or smaller) interference between ball and seat can erode significantly using conventional metallurgy.

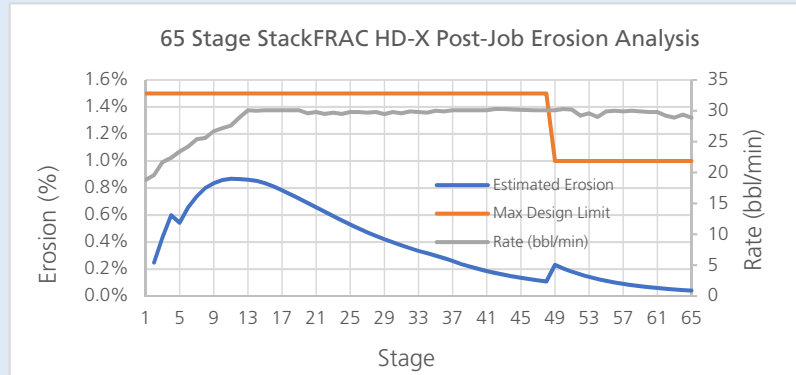
Using tougher materials to withstand heavy abrasion is an effective solution, although it is more costly. Harder alloys can reinforce specific areas along the slurry flow path. Ball seats can be reinforced with hardened anti-erosion coatings. For ultra-high proppant stimulations, coatings can also be applied on the inner surface of sleeves.

For limited entry point systems, the QuickPORT IV ports are reinforced with tungsten carbide. This prevents entry point erosion typical of plug-and-perf, facilitating even distribution among the entry points in a stage.

65-Stage Post-Completion Erosion Analysis

An operator working in the U.S. Bakken wanted to increase stage counts to economically achieve the best reservoir coverage and production. Although the operator was already familiar with ball-activated systems, there was some concern about potential erosion in these systems.

A 65-stage StackFRAC HD-X system was used in a well with a 9,950 ft lateral.



The post-completion analysis confirmed that the estimated erosion for over half the seats were less than 0.5%, with none having lost more than 0.9%. These were well below maximum design limits.

3. Quality Control for Precision and Reliability

Packers Plus is ISO 9001 and API Specification Q1 certified for manufacturing, operations, and engineering processes. From design through manufacturing, assembly, testing, shipping and installation, a fully integrated QA/QC process helps to ensure consistency on every well.

- To achieve consistent precision, all tools can be measured to within 0.0001 of an inch
- Automated torque testing and pressure testing up to 15,000 psi
- Balls are scanned using ultrasonic and 3D lasers for surface defects, ovality, thickness, and dimension with 0.003-in. tolerance
- For full traceability, each tool is imprinted with a unique bar code which stores data such as material and dimensions, test results, inspections, shipping, and downhole position
- Experienced field hands are on location to manually check the size and order of tools during installation and stimulation

These precautions are intended to provide reliability that reduces the possibility of the cost and risk of downtime during operations.

CONCLUSION

As the industry recovers from the recent downturn, operators continue to seek better ways to get the most out of their wells. Since higher proppant volumes have been correlated to better production, stimulation programs in North America now routinely pump hundreds of thousands of pounds of proppant per stage.

Packers Plus completion systems have been specifically designed to meet this challenge, striking the balance between a proppant-heavy stimulation and cost-effective solutions that prevent failure due to erosive tool damage.

LOOKING FORWARD

Innovation has always been critical to the success of Packers Plus, who have continually adapted to meet industry demand. These proven technologies have enabled operators to push the boundaries of unconventional oil and gas completions to increase well productivity.

For more information on Packers Plus solutions, go to packersplus.com.