

Innovus™ Convertible frac sleeves deliver impressive bullhead injection distribution in Viking waterflood

Background

Waterflooding is a common method of secondary oil recovery in unconventional shales that can boost production and recovery by 20 to 40%. Waterflood effectiveness, however, has been limited by uneven water injection along the lateral, leading to inefficient sweep patterns and “short circuits” that bypass significant recoverable oil. To date, operators have had limited options for managing the injection profile, whether in new-drill or converted production wells. The two most common options are:

- Bullhead injection down unsegmented production casing. In an attempt to improve distribution, operators have employed chemical and polymer diverters and mechanical diversion utilizing bridge plugs and isolation packers, with unsatisfactory and unpredictable results.
- At a higher cost, operators can segment a wellbore by installing retrofit systems comprising injection-control devices and isolation packers on production tubing; however, orifice plugging and erosion inevitably degrade sweep performance, leading to costly intervention operations.

Now a new option offers both sweep efficiency and economy: the Innovus Convertible frac sleeve, from NCS Multistage.

Innovus Convertible frac sleeves: a more effective waterflood injection solution

Installed as part of the original completion string, Innovus Convertible frac sleeves can be converted post-frac or post-production to a regulated water-injection mode in a simple coiled-tubing operation. Innovus Convertible sleeves have two inner sliding barrels: 1) the primary barrel, which is shifted to open the frac ports for stimulation and to re-close selected ports if and when needed; 2) the secondary flow-regulation barrel, which is shifted into position across the frac ports to convert to the injection mode.

During completion, a coiled-tubing-deployed (or stick pipe) frac-isolation assembly locates each sleeve, isolates the target zone from the wellbore below, and shifts the primary barrel to open the sleeve ports for fracturing. Later, either

immediately after stimulation or after a period of production, a hydraulic stroke/shift tool is deployed on coiled tubing (or stick pipe) to shift the secondary barrels into position across the sleeve ports, converting the sleeves to injection mode. At all times, the wellbore is full-drift. *NOTE: Both barrels can be shifted back to the closed position later to shut off problem intervals.*

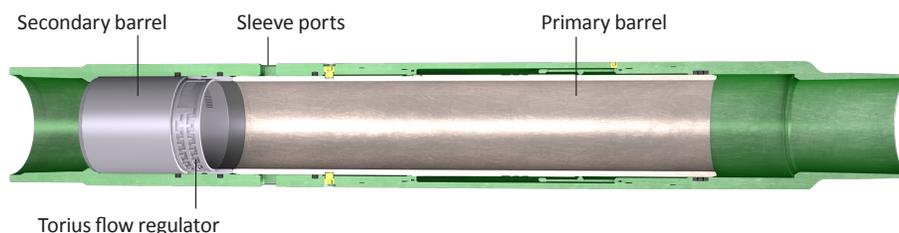
Injection flow is regulated by the integral Torius™ calibrated tortuous flow path in the secondary barrel. The Torius path induces back pressure without relying on small-diameter metering orifices that are prone to erosion and plugging. Torius flow regulation is available in a range of fixed flowrates.

Injection performance in the Viking formation, western Saskatchewan

In 2019, in Saskatchewan’s Viking Field, Whitecap Resources Inc. deployed 13 and 17 Innovus Convertible frac sleeves, respectively, in two new-drill injector wells that were planned to drive residual oil to four nearby producing wells. Both wells were stimulated to improve injection conductivity, and then, on separate coiled tubing runs, the sleeves were shifted to the injection mode. Both wells were then placed on bullhead water injection, with no wellbore segmentation.

Injection distribution all the way to the toe

Although offset production results are not yet available, injection profiles for the two wells were subjected to distributed temperature surveys (DTS) performed by Voltage Wireline, Inc. A DTS fiber optic cable was deployed via fiber optic e-line inside coiled tubing to measure fluid temperature along the wellbore in both wells. DTS provides a quantitative contribution profile across all injection zones based on simultaneous measurements over time. After a baseline survey was conducted, water injection was initiated and held steady for approximately 8 hours. Then the wells were closed in, and temperature surveys were conducted throughout a 3-hour warm-back period. Cooler zones on the DTS logs indicate higher fluid flow, while warmer zones indicate restricted or no flow.

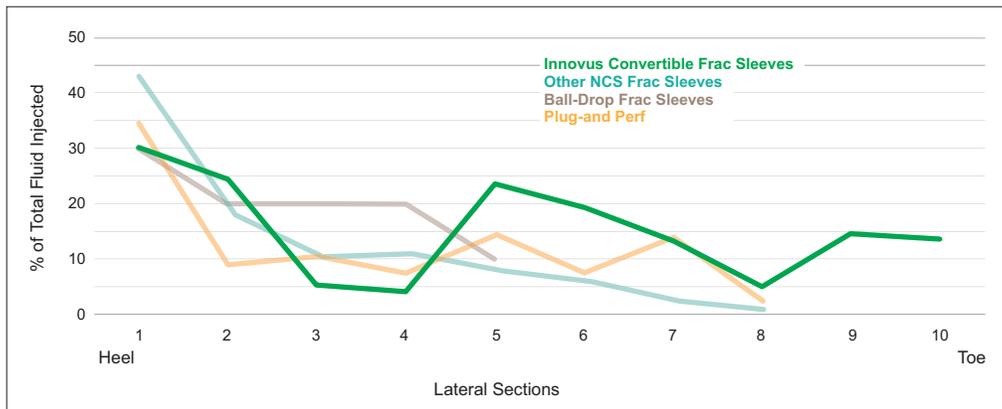
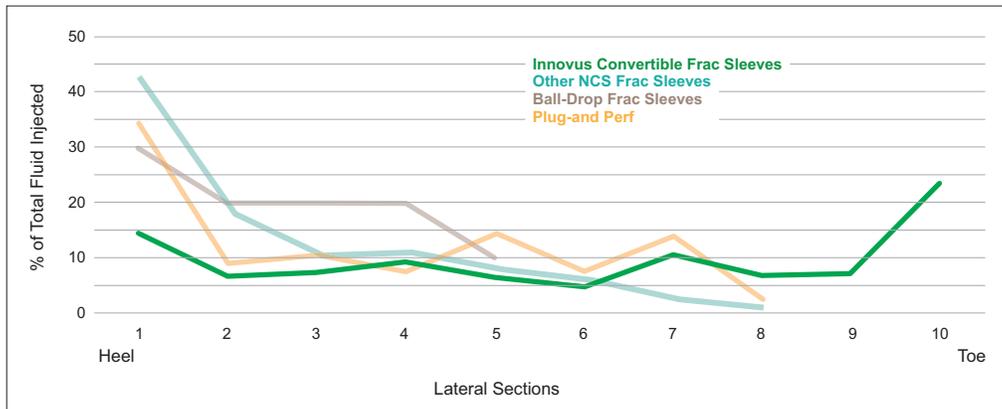


The Innovus SD Convertible frac sleeve

DTS results for the two wells are shown below. The two subject wells are compared with averaged results from all other Viking wells that were tested by Voltage Wireline, including plug-and-perf, ball-drop sleeves, and standard (not convertible) NCS coiled-tubing frac sleeves. To facilitate comparisons, all laterals were “normalized” by dividing them into 10 equal sections, regardless of length.

Conclusion

The charts show that Innovus Convertible frac sleeves effectively reduce heel-dominated injection and deliver superior injection fluid distribution along the entire lateral. In fact, this is the only bullhead injection technology that delivered effective distribution all the way to the toe of the well.



The injection profile comparisons above show that only Innovus Convertible frac sleeves mitigate heel-dominant flow to deliver distributed injection along the entire lateral to the toe. Ball-drop sleeve completions showed no injection for the bottom 50% of laterals, and plug-and-perf completions and other coiled tubing sleeve completions delivered little or no injection for the bottom 30% of laterals.

“From our experience, the Innovus Convertible system provided the greatest distribution of injected fluid across the entire lateral, providing mitigation of heel-dominated flow and optimized flood efficiency. These results were confirmed by wireline-conveyed DTS surveys.”

Brad Jennings, Senior Operations Engineer, WCP-Viking

“The DTS Water Injection Fall-Off Analysis showed an even fluid distribution profile when logging the two wells with the Innovus Convertible Sleeve system in place. We typically do not see such even injection distribution with other completion systems.”

Corey Quirion, Voltage Wireline, Inc.