

# Polymer Treatment Controls Fluid Loss While Maintaining Hydrocarbon Flow

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The loss of pumped fluids that are circulated from surface to total depth (TD) and back during various drilling, completion, and intervention operations poses numerous problems affecting wells and reservoirs. Fluid loss (FL) to the formation is costly not only in terms of the fluid itself, diverted from its task, but in the time and expense required to mitigate the problem. Well control can be compromised, wellbore cleanouts impaired, and reservoirs

damaged, sometimes permanently, as a result of fluids entering the formation.

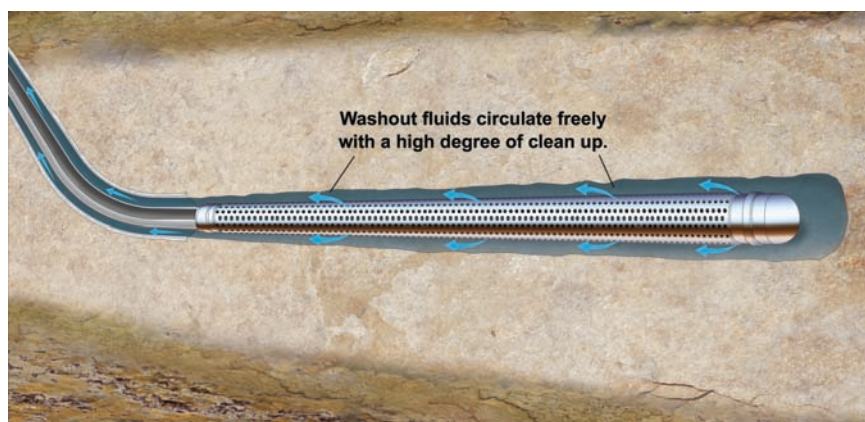
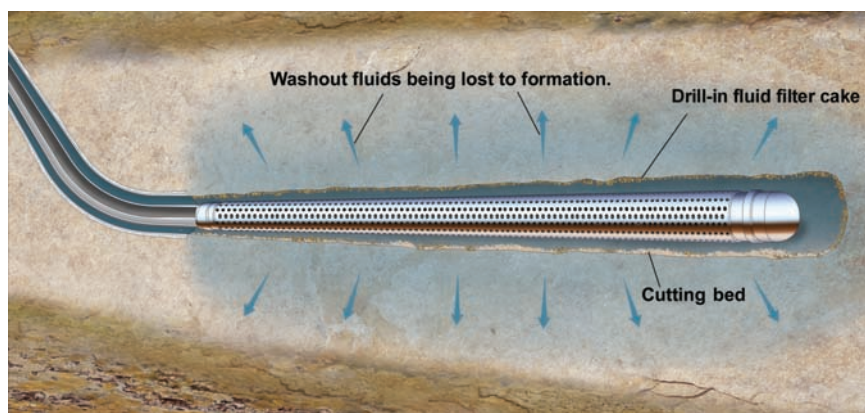
A low-viscosity, solids-free FL treatment can help (1) cure lost circulation, (2) prevent loss of expensive drill-in fluid during workovers, (3) improve well control by maintaining a hydrostatic column, and (4) provide FL control in vertical- and horizontal-well gravel-packing operations.

The treatment technology, developed by Halliburton as the LO-Gard

fluid-loss-control system, relies on an associative polymer to decrease matrix permeability to aqueous fluids, limiting leakoff into treated zones. A significant property of the treating fluid is that it causes little or no damage to the flow of hydrocarbons.

The treatment fluid may be used in various applications.

- Well intervention cleanouts by coiled tubing and hydraulic workover
- Gravel packing
- Most lost-circulation events occurring during cementing, fracturing, and drilling
- After tubing-conveyed perforating (TCP) operations
- FL control before, during, and after gravel packing
- Electrical submersible pump (ESP) replacement operations
- Circulation maintenance in horizontal openhole completions across unconsolidated sands (**Fig. 1**)
- Formation permeability reduction in
  - High-permeability streaks
  - Thinned or eroded drill-in fluid wall cake
  - Breeched or fractured wall cake
  - Natural- or hydraulic-fracture networks



**Fig. 1—Lack of effective leakoff control can result in poor cleanout due to losing fluids to the formation (top). Good cleanout achieved with an associative-polymer treatment can help significantly improve production results (bottom).**

## FL Problems and Causes

During workovers, gravel-pack completions, ESP replacement, underbalanced TCP (UTCP), and other applications, aqueous well fluids are usually circulated continuously between the surface and TD. Maintenance of a hydrostatic column is necessary for well control and to enable treatment fluids to be injected into the targeted intervals downhole, without fear of overdisplacing the treatment fluids.

Fluid losses to surrounding formations often result in loss of circula-

# Unconventional Reservoirs: Selective Multistage Fracturing

## New System Integrates Level 4 Multilateral With Multistage Fracturing to Cut Costs and Optimize Production in Granite Wash

The Granite Wash, in the Northern Texas Panhandle and Western Oklahoma, is a series of thick layers of rubble accumulated on the flanks of a buried granite highland. The partly decayed felspathic detritus has inter-fragmental porosity in which large amounts of gas and also some oil are stored.

### Multiple Challenges in a Difficult Formation

The Granite Wash is a difficult-to-drill formation that also requires—as with many unconventional gas plays—fracture stimulation to achieve commercially successful production. If one multilateral wellbore could take the place of two, then substantial savings could be realized. For a multilateral in this formation to be successful, production would have to match or exceed the rates expected of two single horizontal wells. A further challenge is the need for a multilateral system with the design criteria needed to properly complete the wells for selective re-entry and selective stimulation of stages in each wellbore.

### TAML Level 4 With 10,000-psi Seal Across Junction

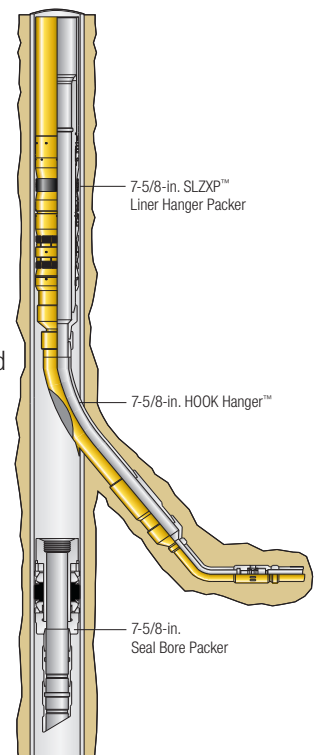
For two multilateral wells in the Granite Wash, plans required TAML Level 4 isolated junctions to both laterals in each well, rated to a 10,000 psi burst differential. Mechanical integrity across the junction window and full-opening access to 4-1/2-in., 11.6-lb liners were also required. The Baker Oil Tools HOOK Hanger™ system met these requirements and added the ability to selectively re-enter each wellbore for additional stimulation treatments later.

Baker Oil Tools composite bridge plugs were used in the cemented lateral in the first well to isolate and stimulate multiple stages. The other lateral in the first well and both laterals in the second well were openhole completions.

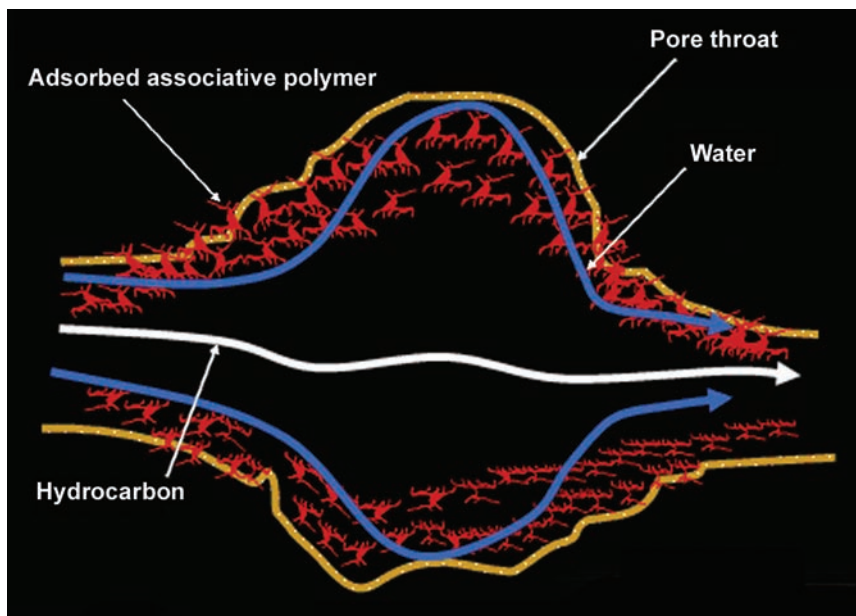
In these laterals, the Baker Oil Tools Frac-Point™ openhole fracture completion system was used to isolate multiple stages for stimulation. The Frac-Point system is an integrated component of the HOOK Hanger system that is ideal for multistage isolation in multilateral wellbores. No other completion system has this combination of proven capabilities.

### Production Targets Met, With Lower Costs

Production results from both wells compared favorably to offset wells. For each well, the operator believes initial production rates exceeded what could have been expected from two single lateral wells. Just as important, drilling and completion costs were an average of 13% lower than drilling and completing two single-lateral wells. The unique combination of capabilities offered by Baker Oil Tools' HOOK Hanger system, Frac-Point system, and composite bridge plugs again proved to be ideal for meeting the tough economic and technical challenges of unconventional reservoirs like the Granite Wash.



*The Baker Oil Tools HOOK Hanger™ 10,000 psi sealed junction allows operators in unconventional reservoirs to drill and case two 4-1/2-in. laterals out of 7-5/8-in. casing and use conventional fracturing methods for stimulation.*



**Fig. 2—Associative-polymer adsorption increases hindrance to water flow.**

tion (LC). LC contributes to poor well cleanout (due to low fluid velocity and flow volume), costs from loss of expensive well fluids, rig-time expense, cost of materials and time in attempts to remedy the FL condition, and loss of reserves, resulting from reservoir damage caused by fluid leakoff into the formation. Further, if solids or high-viscosity fluids are pumped into the reservoir in attempts to resolve the LC problem, the reservoir can be damaged permanently or may require extreme, often expensive remedial measures to restore production.

FL can occur in cased-hole work-over applications, or well-completion operations such as running tubing and production equipment when open perforations are exposed to solids-free brine well fluid. Other occurrences of FL can be

- After UTCP, when undamaged, high-permeability reservoirs are exposed to filtered, solids-free brine, where fluid-column hydrostatic pressure exceeds reservoir pressure.

- During completions, when fluids flow into a permeable formation or zone rather than circulating back up the borehole.

In openhole completions, FL can occur when pressure surges (induced by pipe movement) during well operations breach or lift low-permeability drill-in fluid filter-cake barriers. Other

factors contributing to FL in openhole wells are

- Improperly designed or operated downhole tools and gravel-pack service tools, which can cause interruption of positive hydrostatic column pressure, or swabbing.

- Equivalent circulating density (caused by circulation rates) that exceeds formation breakdown pressure.

### The FL-Treatment Technology

The FL treatment, as mentioned, includes an associative polymer. Associative properties result in, essentially, weak crosslinks between polymer chains. It is well known that the solution and adsorption properties of water-soluble polymers are uniquely modified when associative properties are introduced. In particular, the associative properties result in increased levels of adsorption onto surfaces, as compared to a similar nonmodified polymer.

It has been shown that various polymers will adsorb to rock surfaces and decrease water permeability, with minimal effect on hydrocarbon permeability (Zaitoun and Kohler 1989; Eoff, et al. 2003). In a water-wet formation producing hydrocarbon, it is generally accepted that water flows along the pore-throat walls while hydrocarbon flows through the middle of the pore throats. A layer of adsorbed polymer can hinder water flow with little or

no effect on hydrocarbon flow. When using an associative polymer, the result is a much thicker layer of adsorbed polymer, which results in a higher level of hindrance to water flow while still maintaining the minimal effect on hydrocarbon flow (Fig. 2).

Laboratory tests have shown the effect on water and hydrocarbon permeabilities. In these tests, one core was taken to residual oil saturation and one was taken to residual water saturation. Both were treated with the associative-polymer solution and then flowed with either water or oil to determine the final permeability. The water permeability was decreased by 98% while the oil core actually showed no change in oil permeability.

Laboratory testing has demonstrated the capability of the associative polymer to act as an FL control agent. In this test, a hollow sandstone core was used, in which a mud filter cake could be built on the inner portion of the core. The drilling fluid was then displaced with 7% KCl and this was then held at a constant pressure differential. At approximately 0.5 hours, a rapid breakthrough of the 7% KCl occurred, such as might be seen when a filter cake is compromised during a gravel-pack operation. Following this rapid leakoff, the 7% KCl was displaced with the FL treatment, under the same differential pressure. The leakoff rate slowed tremendously and was maintained for approximately 19 hours. After switching back to 7% KCl, the same low leakoff rate was maintained.

### Case Histories

**Case 1.** In West Africa, an operator needed to replace an ESP in a cased-hole oil producer and anticipated high FL to the formation. Bottomhole temperature (BHT) was 131°F (55°C), and seawater was used as the completion fluid. To control losses, two 40-bbl associative-polymer pills were bullheaded. Fluid losses, before treatment, were 214 bbl/hr (567 L/min). After the two treatments, FL dropped to 26 bbl/hr (69 L/min), an almost 90% reduction. The treatment controlled the losses for 2 days, providing enough time to remove and replace the ESP and avoid formation damage.

(Contd. on page 34)

local governments, and possess local knowledge, which is of crucial importance when building business sustainability and working with local subcontractors, unions, and community stakeholders. Another advantage is that a majority of the technical training in petroleum and other engineering disciplines can be provided in any part of the world and often at a much lower overall cost than in Europe or the US.

Some oil and gas companies have appointed regional recruitment directors and established policies to recruit in a wide geographical area, in particular in countries where they operate. There are, however, two important conditions to make these recommendations effective.

First, human resource planning has been, for many years, the stepchild of the oil and gas companies. Being a capital-intensive industry, the boards of most companies focus on investment planning, marketing strategies, and other key issues. Human resource planning is often relegated to the lower echelons in the hierarchy. This needs to change. Human resource planning needs to be upgraded to the board room. The proposals for avoiding future skills shortages are unlikely to be implemented

successfully without the backing and support of the board room.

A second condition for these policies to work is to set up mechanisms facilitating collaboration and coordination among oil and gas companies. In the past, oil and gas companies have mostly responded individually, and without coordination, to skills shortages. But a strategy of “going it alone” is unlikely to produce optimal results. The impact will be larger if the industry takes joint action on any of these proposals.

There are many examples, from the past, of other industries facing serious challenges and deciding to join forces because the challenges are too big and individual responses not adequate. The prospects of yet another major skills shortage in the oil and gas sector is a challenge easier to meet when there is effective coordination and collaboration among companies. Joint action could start, for example, by establishing a mechanism to collect data from companies to produce an accurate forecast of aggregated global demand and supply of skills in the industry. A forum could also be established to exchange views, information, and decide where joint action is needed. **JPT**

## TECHNOLOGY UPDATE (Contd. from page 30)

**Case 2.** An operator in South America had performed three bare-screen completions, in which fluid losses prevented the continuation of full circulation returns while displacing horizontal openhole pay sections to filtered completion brine. The best of the wells was producing 4,500 bbl of fluid per day. The underperformance was attributed to fluid losses and reduced circulation rates, leading to poor cleanout of openhole lateral pay intervals. Low-velocity rates would not remove drilling debris and drill-in fluid residue from the laterals. Under production, the debris plugged the sand screens.

On the fourth bare-screen completion, the operator and service company followed these steps:

1. Ran into the wellbore to depth in the lateral, circulating the open hole full with filtered completion brine; fluid losses were 40 bbl/hr (106 L/min).

2. Placed a 50-bbl carbonate pill in the lateral; fluid losses were reduced to

16 bbl/hr (42 L/min). This level of loss was still too high.

3. Ran a 35-bbl (one openhole volume) associative-polymer treatment; fluid losses decreased to 2 bbl/hr (2 L/min)

4. Circulated the well to filtered brine; FL was low enough to give static fluid conditions without measurable losses during screen-running operations.

**Case 3.** The service company was attempting to clean formation sand out of a well by means of a foamed-gel application. The sandstone formation was perforated from 5,820 to 5,380 ft, with BHT of 160°F and permeability of approximately 30 md. The goal was to clean the well from 5,820 ft down to a drillable bridge plug at 6,470 ft. When the cleanout work string was washed down to the perforated interval, circulation fell off dramatically. Service company operators increased foam quality and tried varying pumping techniques, but could not re-establish circulation. The operators then spotted two 10-bbl asso-

ciative-polymer pills across the perforated interval and immediately regained 100% circulation. The cleanout was completed with no further circulation losses. The well resumed production without any problems observed, and production stabilized at a rate significantly higher than before the treatment.

## References

- Eoff, L., Dalrymple, D., Reddy, B.R., Morgan, J., and Frampton, H. 2003. Development of a Hydrophobically Modified Water-Soluble Polymer as a Selective Bullhead System for Water-Production Problems. Paper SPE 80206 presented at the 2003 International Symposium on Oilfield Chemistry, Houston, 5–8 February.
- Zaitoun, A. and Kohler, N. 1989. Improved Polyacrylamide Treatments for Water Control in Producing Wells. Paper SPE 18501 presented at the 1989 SPE International Symposium on Oilfield Chemistry, Houston, 8–10 February. **JPT**