Better fracturing fluid cleanup can translate into improved production. Recent third party testing has shown that ViCon NF™ breaker provides unsurpassed cleanup and retained permeability (Figure 1). It is effective in breaking both fracturing fluid and filter cake.

ViCon NF breaker offers major advantages over conventional breakers for fracturing treatments in 150 to 350° F conditions:

- Can be run at high concentrations without harming short-term fluid rheology and proppant transport. Unique chemistry and high temperature of activation enable the use of ViCon NF breaker at higher concentrations than typical oxidizer type breakers for highly effective cleanup (Figure 2).

- Reservoir minerals have little effect on its capacity to decompose polymer gels (unlike all other conventional breakers).

- The water soluble breaker stays with the fluid during leakoff and flowback.

- Removes gel filter cake for higher retained permeability.

- Remains reactive days after persulfates and enzymes are spent.

- Secondary catalyst can be used to lower the activation temperatures to provide the same advantages at lower temperature ranges.

- Can be run throughout the entire treatment.

**Specifications**

Because ViCon NF breaker is a water-based solution containing no insoluble material, it maintains its activity in the fluid during leak off. It is useful with all fracturing fluids with a pH range from 6 to 12. It may be added throughout the treatment—from pad to flush. The breaker is highly effective in both low and high permeability formations. In high permeability formations, it can help increase production where a soluble breaker is needed.
ViCon NF Breaker Improves Fracture Cleanup From 45% To Nearly 100%

In laboratory testing, no other commercially used breaker has shown cleanup reliability comparable to ViCon NF breaker. In Figure 3, the blue and magenta lines are the expected clean-permeability lines for a dry pack and one at 15% $S_w$ (this is the typical residual water saturation after flowing gas through a water-saturated pack). The arrows show the direction of change in flow rate for the lab test.

The green points show the cleanup profile of the fluid with no breaker. As gas rate increases from 200 MSCF/D to 1 MMSCF/D the apparent perm actually drops slightly. Once the rate exceeds 1 MMSCF/D the perm begins to increase. The gas rate was increased to almost 3 MMSCF/D then decreased. During the declining rate period the data parallels the wet-pack curve. This means that permeability is being controlled by non-Darcy flow, but that the base permeability of the pack is constant. The gel-damaged pack cleans up to about 25-30% of the flow capacity of the wet pack.

The blue data points show the same cleanup profile for a typical persulfate breaker loading. Using any more than this amount leads to fluid instabilities, poor proppant transport, and early screenouts. With a “normal” amount of breaker the gel cleanup doesn’t start until gas rate exceeds 1 MMSCF/D. Ultimate cleanup is 40-50% of the pack permeability at 15% $S_w$. Adding more of this breaker is not an option because of loss of fluid stability.

The ViCon NF breaker cleanup profile is shown by the red points. Even at rates as low as 300-400 MSCF/D the pack cleans up and permeability increases almost to the 15% $S_w$ line. The permeability follows the clean-pack trend for increasing rate and then retraces its path as rate is decreased. Visual examination of the pack after the test confirmed that all visible gel residue and even the wall filter cake were removed.

Figure 3 - The above plot describes the observed cleanup behavior of a typical 35 lb/Mgal crosslinked fracturing fluid at 180˚F with a typical loading of AP breaker and the recommended loading for ViCon NF breaker.
So What Does This Mean In Terms Of Production?

To help with this, the following evaluation was conducted using Predict-K* ver. 6.0. For simplicity, an average well will be used to determine differences in production based on well productivity for different permeabilities over a three-year period. The average well parameters are as follows:

- Drainage Area – 40 acres
- Formation Height – 100 ft
- Initial Pressure – 6,000 psi
- Depth – 12,000 ft
- Condensate Production – 5 bbl/mmscf
- Producing Pressure – 300 psi

Figure 4 shows the difference with and without ViCon NF breaker in cumulative production for various formation permeabilities. For a 0.1 md permeability formation the difference for a propped fracture half-length of 600 feet is over 275,000 MSCF per 100 ft and 400,000 MSCF per 100 ft in 3 years for a 1,200 ft propped fracture.

Understanding Breakers

Water-based fracturing fluids are usually made viscous by the addition of 20 to 70 lb of guar or derivatized guar polymer per 1000 gallons of water. Guar polymer is derived from the beans of a guar plant. A mixture of guar dissolved in water forms a base gel, and suitable crosslinking agents are added to form a much more viscous fluid called a crosslinked fluid. The viscosity of base gel is typically 20 to 50 cp and when crosslinked increases by 2 to 100 times depending on the temperature, test method, and type of crosslinker used.

After the proppant is placed in the fracture and pumping stops, the fracture closes on the proppant bed. The pores of the proppant bed are still filled with the fracturing fluid and must be cleaned out to maximize conductivity of the proppant-filled fracture. Breakers reduce the molecular weight of guar polymer in the fracturing fluid by cutting the long polymer chain. As the polymer chain is cut, the fluid’s viscosity is reduced to near that of water. This process can occur independent of crosslinking bonds existing between polymer chains. The water-thin fluid can then be flowed from the fracture. Unfortunately, another complicating factor exists.

The Filter Cake Challenge

As the hydraulic fracture is being formed and propagated, fluid leaks from the fracture into the formation matrix. As this process occurs, a filter cake of concentrated guar polymer is formed while the water, KCl, and breakers pass into the formation. The filter can be a semi-elastic, rubber-like membrane and can severely damage the permeability of the proppant bed. In general, higher breaker levels are required to remove filter cake than to break fracturing fluids. Breakers must be selected to effectively break the fracturing fluid and remove filter cake.

* Predict-K is a trademark of Core Laboratories
Field Results

Gulf of Mexico - Halliburton’s Delta Frac® fluid system with ViCon NF breaker achieved 0 skins, a significant improvement over the 5-7 skins typical of widely used borate gels with the typical SP breaker used for Gulf of Mexico frac packs. ViCon NF breaker was ramped so that the pad fluid was broken 15 minutes prior to completion of the treatment with break being defined as water thin! (SPE 39897)

Australia - A major integrated reservoir study for a production company found through neural network analyses that the use of ViCon NF breaker along with reduced polymer concentration resulted in a 67% improvement in 12-month NPV.

South Texas - Operator was performing linear and crosslinked CO₂ fracturing treatments at BHTs between 140 to 165˚ F using a conventional breaker package. Production was averaging 200,000 scf/d. Operator wanted more conductivity and longer effective fracture length. After switching to ViCon NF breaker with Cat-OS 1™ catalyst, initial results were very promising. Average production from two typical wells increased to 300,000 scf/d.

ViCon NF Breaker Summary

• Liquid Breaker – Goes with the fracturing fluid.
• Slowly Soluble – Can be run at high concentrations.
• Reactivity – Remains reactive days after persulfates and enzymes are spent.
• Filter-Cake – Removes the gel filter cake resulting in higher regained permeability.

For more information on the ViCon NF™ Fracturing Fluid Breaker, please contact your local Halliburton representative or email us at stimulation@halliburton.com.