What is shaping up to be a game-altering technique for the hydraulic fracturing of low-permeability oil and tight gas formations is now being expanded successfully into the burgeoning shale plays in the U.S.

At the core of this paradigm change is the Schlumberger HiWAY* flow-channel hydraulic fracturing technique, which engineers stable flow channels in the frac proppant pack, creating “highways” for hydrocarbon flow throughout the fractures and back to the well bore.

With the HiWAY service, oil and gas rates are decoupled from the actual permeability of the proppant pack. Rather than flowing through the proppant pack itself, as with conventional fractures, the HiWAY service permits hydrocarbons to flow virtually unimpeded through channels created in the proppant pack. This mitigates conductivity impediments caused by fluid damage, multiphase flow, and non-Darcy effects. Field studies conducted by Schlumberger indicate that fractures completed this way can attain a condition of “infinite fracture conductivity.”

Schlumberger continues to build proof that the HiWAY service can be used to tackle most all lithologies, provided the balance between rock competency and in situ stresses is adequate to maintain open channels within the fractures.

More than 2,100 fracturing stages have been pumped with the HiWAY service to date, with virtually no proppant flowback issues. Also important is that the HiWAY service has attained a 100:1 reduction in near-wellbore screenouts when compared to proppant placement results – in the same reservoirs – using conventional fracturing techniques. These reductions alone have a significant bottom-line impact by improving operational efficiency and eliminating remedial costs.

**HiWAY boosts production**

The HiWAY service has enabled increases in initial production — often exceeding 25% — and in estimated long-term recovery — typically more than 15%.

Under development since 2003, the HiWAY service has undergone meticulous laboratory and field testing. Actual field applications began in 2007 for stimulating single and multi-layered oil and gas wells in sandstone reservoirs. In Argentina, for example, a HiWAY-treated low-permeability well in the Loma la Lata field (Neuquen Basin) posted an average initial production rate of 8.9 mmcf/d compared to 6.4 mmcf/d from a number of similar wells stimulated conventionally. Also, after two years of cumulative production time, the HiWAY well had produced 4.5 bcf of gas compared with an average of 3.5 bcf from the conventionally treated wells.

Meanwhile, wells fractured with the HiWAY technique in northern Mexico (Burgos Basin), and in Russia (Western Siberia) also yielded positive production results.
Since it was commercialized in 2010, the HiWAY technique has been applied in vertical wells for economically stimulating sandstone and carbonate reservoirs in several regions of the world, including the U.S. Rocky Mountains (Johah field), where complex tight gas sands require multi-stage completions (typically 10 to 16) – with the deepest stages at more than 12,000 ft; and in oil plays such as central Mexico (Chicontepec) and Oman (Al-Noor). Initial production results in these areas were superior to those delivered with conventional techniques.

Plans for the near future include implementation in Saudi Arabia, Algeria, Egypt and Canada, among other countries. As noted, Schlumberger also has expanded the HiWAY service to include unconventional oil and gas plays in the U.S., with successful applications already underway in the Eagle Ford shale as described later. Recent trials also have been conducted in the Bakken and Barnett shales, and preparations are ongoing for application in the Marcellus and other major U.S. shale plays.

The HiWAY way

A geomechanical model developed specifically for the HiWAY service has been incorporated into the Schlumberger fracture design tools. The company’s proprietary FracCADE* fracturing design and evaluation software is used to qualify HiWAY service for a specific reservoir. A pre-fracturing completion strategy, or perforation placement plan, is then engineered to promote channel formation. The perforation scheme consists of clusters of perforations separated by non-perforated intervals, which is important to achieve more uniform distribution of the proppant conglomerates across the fracture height and to attain optimum channel geometry.

A gelled fracturing fluid and a fit-for-purpose fiber are combined continuously at the well site using specialized mixing equipment. Proppant is added intermittently in high-frequency pulses, each proppant-laden pulse followed by a slug of proppant-free gelled fluid. The company’s PodSTREAK* stimulation blending, monitoring, and control unit or SuperPOD* blenders are used for these operations.

The proprietary fiber employed with the HiWAY service helps keep the proppant pulses cohesive, preventing them from dispersing as they are conveyed from the surface down into the completion. It also improves the fluid-proppant-fiber slurry’s carrying capacity to transport the proppant pulses more smoothly. And lastly, the fiber helps to suspend the pulses within the fractures, thereby preventing proppant from settling before the fractures close.

Channeling unconventional reservoirs

Working in the Hawkville Field near Cotulla, Tex., the field’s operator had the goal of increasing gas and condensate production from the Eagle Ford formation. The formation poses difficult challenges with fracture gradients ranging from 0.91 to 1.00 psi/ft and bottomhole temperatures ranging from 270°F to 325°F at depths of 10,000 to 13,000 ft. Permeabilities are in the range of 200 nD to 600 nD, and porosities range from 6% to 10%. Bottomhole pressures range 7,000 to 10,000 psi, and Young’s Modulus range between 2.0 to 4.5 Mpsi.

Horizontal Eagle Ford wells are traditionally treated as a recent switch to hybrid treatments has led to moderate improvements. Two wells, one gas and one condensate, were treated using the HiWAY flow-channel fracturing technique. The results showed that the HiWAY-treated gas well had 37% higher initial production than the best offset wells. And the condensate well had 32% better production compared to its best offset. The increases in production that were attained for the first two wells have been confirmed in a field-wide study comprising fifty wells. More than 1,000 stages have been completed with HiWAY service for seven companies operating in the Eagle Ford formation to date.

*Mark of Schlumberger
