A new hydraulic fracturing technique has been developed that fundamentally changes the way a hydraulic fracture increases the effective near-wellbore reservoir conductivity. It decouples fracture conductivity from proppant pack permeability by creating stable flow channels. Instead of flowing through the proppant pack, hydrocarbons flow preferentially through these channels, enormously increasing conductivity.

The network of channels extends from the near-wellbore region to the tip of the fracture. It allows for longer effective fracture half-lengths, lower pressure drops along the fracture, and better fluid and polymer recovery. These effects contribute to optimized production and hydrocarbon recovery. After thorough laboratory testing, the technology has been deployed in several countries. One company, YPF SA, has achieved improvements in average gas production per well by employing the technique in its Loma La Lata (LLL) field in Argentina.

**Improving fracture production is a universal need**
Several strategies have been developed to improve fracture production, such as enhancing proppant roundness to optimize its conductivity, lowering proppant crush and gel loadings, and improving gel breakers. However, permeability of the proppant remains a fundamental limitation because fluids can flow only through the spaces between the proppant grains. The HiWAY flow-channel hydraulic fracturing technique developed by Schlumberger changes the way fracture conductivity is generated.

A combination of placement, completions techniques, fluid engineering, and process control creates a complex network of stable flow channels within the fracture. Rather than flowing through the proppant pack, hydrocarbons flow through channels with effective infinite conductivity. By changing the way hydrocarbons flow, the technique ensures that traditional proppant pack conductivity losses – including crushing, fines, fluid damage, multiphase flow, and non-Darcy effects – are overcome.

**Advanced fiber technology**
The flow-channel hydraulic fracturing technique is the result of an integra-
tion of placement and materials engineering, surface equipment and fiber material expertise, and extensive fracturing experience. Specialized completions strategies and process control equipment enable the technique to provide optimal recovery. The stability of flow channels is maintained by using a proprietary fiber that protects the structure from surface to reservoir until the fracture closes and the *in situ* stress takes over.

The new technique currently can be applied for hydraulic fracturing applications in competent rock for single and multilayer oil or gas wells with formation temperatures from 100°F to 250°F (38°C to 121°C). It has been deployed successfully in Argentina, Russia, Mexico, and the US. To date, more than 200 stages have been pumped without the occurrence of screenouts. In Argentina, the technique has been used in more than 20 wells in the LLL field.

**Enhanced production at LLL field**

The LLL field lies approximately 60 miles (96 km) northwest of Neuquén in southwest Argentina. Its hydrocarbons are mainly gas and condensate. With more than 300 active wells, it is the main gas producer in the country, accounting for 26% of total national gas production.

The largest accumulations of gas are in the central Neuquén Basin, where the Sierras Blancas formation is the main producing reservoir. From the late Jurassic period, this formation was deposited in different non-marine environments characterized by two lithofacies associations: green-gray Aeolian sandstones at the top and red fluvial sandstones at the bottom. Hydrocarbons are predominantly in the flank of an anticline in the fine- to

In the buildup test analysis, data interpretation became insensitive to fracture conductivity, indicating the fracture was infinitely conductive.

Estimated ultimate recovery for a well treated with HiWAY was compared with a conventionally stimulated well based on nearly two years of production data.
coarse-grained Aeolian sands. The reservoir has an average depth of 9,500 ft (2,896 m), an initial reservoir pressure of 4,500 psi, and a bottom-hole temperature of 240°F (116°C).

Despite continued drilling and fracturing activity, gas production has declined in the LLL field. This situation, combined with increasing demand, prompted YPF SA to seek new well stimulation methods. The HiWAY flow-channel hydraulic fracturing technique was subsequently applied in several parts of the field.

**Well results**

The new technique was used to stimulate a well in a reservoir formation with porosity from 12% to 17%, permeability from 0.1 to 5 mD, and Young’s Modulus from 4 to 7 million psi. A nearby well was stimulated using a conventional fracturing technique. Post-fracture drawdown and buildup tests for the channel-fractured well showed the fracture conductivity to exceed the data interpretation’s sensitivity, indicating the fracture was infinitely conductive.

The initial production rate for the well treated with channel fracturing was 30% more than that of the conventionally fractured well (4.4 MMcf/d versus 3.4 MMcf/d). From nearly two years of production data, estimated 10-year economic ultimate recovery from the channel-fractured well was calculated at 47% (0.7 Bcf) higher than the conventionally treated well.

In another part of the LLL field, the flow-channel hydraulic fracturing technique was applied to one well with declining production while two nearby wells were treated conventionally. After treatment, the conventionally stimulated wells saw average initial production rates of 6.4 to 7.6 MMcf/d of gas, while the well stimulated with channel fracturing had an initial production rate of 8.9 MMcf/d of gas. This difference represents a 40% increase in gas production over conventional techniques. After two years of cumulative production time, the conventionally treated wells had produced 3.5 Bcf of gas each, while the HiWAY well had produced 4.5 Bcf of gas, a 29% increase.

In another field study, seven wells were stimulated with HiWAY, while eight comparable wells in the same area were stimulated using a conventional fracturing technique. Average initial production rate for the conventionally stimulated wells was 5.4 MMcf/d of gas, while those that used the new flow-channel fracturing technique saw an initial production rate of 8.2 MMcf/d of gas. This difference represents a 53% improvement in gas production over the conventional technique. Recoverable reserves are expected to increase by 15% over 10 years, representing an average increment of 1 Bcf/well.

The technique has been implemented in several other fields with a job count that exceeds 200 treatments. To date, results indicate that the technique not only delivers higher initial production rates, but also sustained production gains over time.

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The wells treated with HiWAY show consistently higher performance than conventionally stimulated wells.

Initial gas production of HiWAY wells showed a 53% improvement over conventionally treated wells.