

## Technology Update

### New Methods Boost Multistage Fracturing in Horizontals

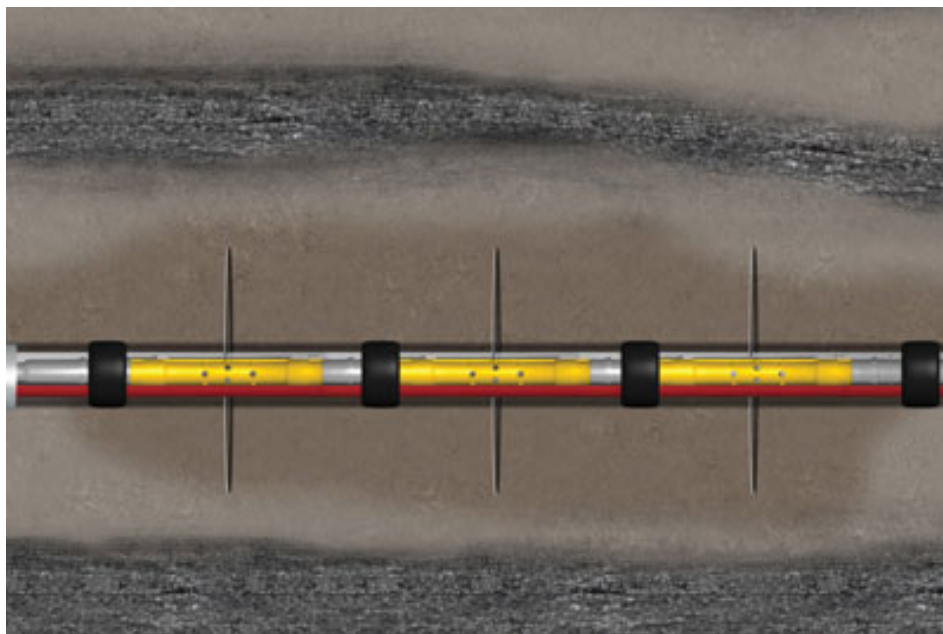
In horizontally completed wells, as in those that are vertically completed, underachieving wells are commonplace. There are many potential causes; however, this problem often can be attributed to one or more of the following circumstances:

- Permeability anisotropy, tending to limit vertical permeability especially
- Skin damage or near-wellbore plugging of a natural fracture network
- Ineffective stimulation techniques

Fracturing technology for horizontal wellbores continues to evolve. The technique of using the dynamic movement of fluid to divert fluid flow into a specific point in the formation has proved effective in creating and accurately placing fractures in openhole horizontal wellbores. A need for equally effective advanced stimulation technology has existed for cased horizontal wellbores. Two new developments by Halliburton, extending the scope of completion and fracturing technologies, are enabling operators to fracture cased horizontal wellbores more effectively: sliding-sleeve completions and coiled-tubing (CT) fracturing applications.

### Sliding-Sleeve Completions

The use of sliding sleeves for horizontal cased-hole fracturing is being adopted rapidly by the industry. This method (**Fig. 1**) provides operators with another well-architecture option for completing multizone wellbores effectively and economically with minimal or no intervention. The technique uses two newly developed tools—a stimulation sleeve and a swellable packer—to enable selective access to multiple pay zones in a single wellbore, with the option of closing or opening one or more zones at a later date.



**Fig. 1—A sliding-sleeve completion with swellable packers enables completing multizone wellbores with minimal or no intervention.**

Designed to be run as part of the casing string, the stimulation sleeve enables the performance of selective multizone operations through the production string. The sleeve can be operated by using a mechanical/hydraulic shifting tool run on coiled or jointed tubing, or by using a ball-drop system. Opening the sleeve permits zonal stimulation through the selected sleeve and diverts the flow through the ports in the sleeve. After stimulation, cleanup is aided by flowing all lower zones simultaneously. Once cleanup is finished, the sleeve functions as a standard production device, allowing full wellbore access.

The swellable-packer isolation system is a zonal-isolation device based on the swelling properties of rubber in the presence of hydrocarbons and requires no mechanical movement or manipulation to set. It can swell to as much as 200% of its original size to seal the annulus around the pipe, isolating the producing zones. Swelling time can be controlled for each specific application.

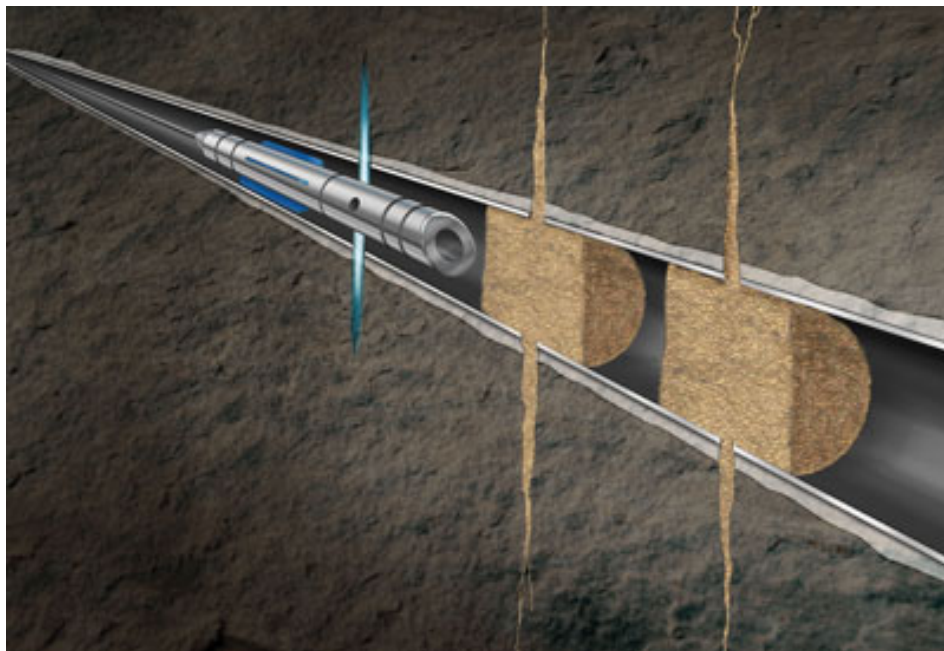
## East Texas Case History

An east Texas operator needed to stimulate five naturally fractured intervals in a multizone horizontal wellbore. Normal cementing-completion methods were not an option because they would restrict production. The operator chose the sliding-sleeve completion process, which included a liner hanger to isolate the formation from the upper wellbore and provide a means to tie back to the surface. The process also included a swellable-packer system to isolate the annular area between zones. Liquid hydrocarbons were introduced into the annulus to swell the packers. The sleeves were opened selectively by dropping balls from the surface. Five zones were stimulated successfully in 20 hours with 1.3 million lbm of proppant and 2.1 million gal of gel in continuous pumping.

## Coiled-Tubing Applications

Horizontal wells are especially prone to curtailed production resulting from flow convergence, the diminished velocity and flow pressure of the hydrocarbon currents caused by friction generated by the cumulative flow from the surrounding reservoir into the constriction near the wellbore. This convergence reduces the flow entering the wellbore. In such wells, treatment methods establishing the highest possible near-wellbore conductivity are needed to optimize production, and aggressive treatment schedules often are required. A CT fracturing technology incorporating a packerless, hydrajetting bottomhole assembly (BHA) has been shown to fracture multiple intervals with greater speed and lower operational risk than conventional methods. The aggressive treatment schedule uses a final proppant pack to maximize near-wellbore conductivity, over-coming the flow-convergence issues and providing fluid diversion between stages. The process can take place without trip-ping out of the hole between treatments.

This application (**Fig. 2**) makes it possible to optimize key treatment parameters such as injection rate, proppant volume, and proppant concentration. A number of benefits result, including



**Fig. 2—The CT fracturing application successfully addresses the flow-convergence effects in fractured horizontals by creating the highest possible near-wellbore conductivity by use of proppant packing at the end of each fracture treatment. In this single-trip process, hydrajet perforating ensures successful pumping of proppant in high concentrations through the erosion of perforation tunnels, eliminating tortuosity (curved flow paths) near the wellbore.**

- Single-trip perforating and fracturing

- No use of mechanical plugs requiring later removal
- Conventional CT rigs can be used, typically 1¾- or 2-in.-outside-diameter units
- No temperature limits on BHA use
- No depth limit other than CT reach
- Fracturing enabled in casing diameters of 3½ in. or greater
- No downhole packer or bridge plug to manipulate
- Operations are always on a live well

The process entails pumping through conventional CT, using hydrajetting to create perforations and initiate fractures. The main fracture treatment is pumped concurrently through the CT/casing annulus.

## South Texas Case History

The majority of the formations in south Texas require hydraulic fracturing to sustain sufficient production. One area operator had tried many different stimulation and completion techniques, including multistage, remotely activated casing-perforation modules; composite plugs; and stimulation valves. All of these methods proved unsatisfactory because of job-related problems or insufficient production achieved. The CT application described above was then tried.

Well conditions included a sandstone formation below 10,000 ft with bottomhole static temperature of 295°F and production casing provided by a 3½-in. unperforated cemented liner. The objective was to place six distinct fractures in the horizontal section. The treatment used 1¾-in. CT. Slightly more than 1 million lbm of 20/40 ceramic proppant and 0.5 million lbm of 20/40 resin-coated ceramic proppant was placed. The well was flowed back and achieved the highest production in the field with quick treatment payout. The initial test of the process resulted in doubling the initial production rate of 16 MMscf/D, compared with an offset well. Ten additional wells for this operator have been treated with the CT application, and nine more treatments have been performed for different operators in south Texas.

Worldwide, more than 50 horizontal wells have been stimulated with this method, most recently at measured depth greater than 17,000 ft and with more than 1 million lbm of proppant used in the treatment. All the wells are holding production significantly better than conventionally fractured wells, in most cases achieving a production increase of more than 50% when compared with limited-entry staged fracturing methods.

The sliding-sleeve completion system and the coiled-tubing fracturing application are field-proven technologies used to create and place fractures accurately in cased-hole horizontal wellbores.

The sliding-sleeve completion system permits zonal stimulation through the selected sleeve and diverts the flow through the opened ports in the production string. The sleeve can be operated through use of a mechanical/hydraulic shifting tool run on coiled or jointed tubing, or through use of a ball-drop system. The ball-drop method is interventionless, while the tubing/shifting-tool option enables aggressive treatments to maximize near-wellbore conductivity, offsetting flow-convergence effects.

The CT fracturing application uses hydrajert perforating to eliminate separate trips into the wellbore and a proppant pack as the final stage of a fracturing treatment for fluid diversion between stages. The proppant pack also helps overcome the flow-convergence issues by maximizing near-wellbore conductivity.

*Information provided by Halliburton.*

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