SurgiFrac® NWB Service

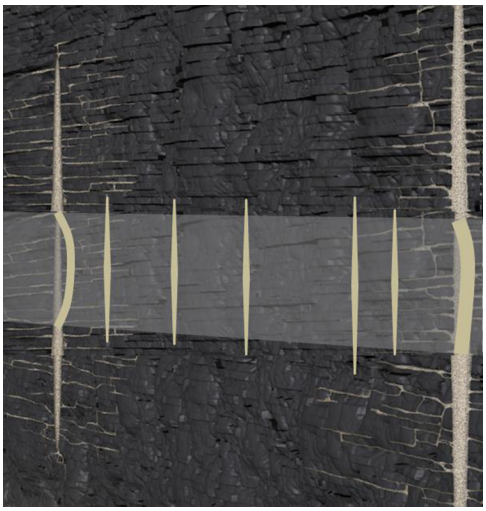
Kuwait Oil Company now produces more than 1,000 barrels of oil per day from wells that had not produced anything for 15+ years.

SurgiFrac® NWB Service created microfractures that helped avoid gas breakthrough from nearby zone.

Location: Kuwait

Overview

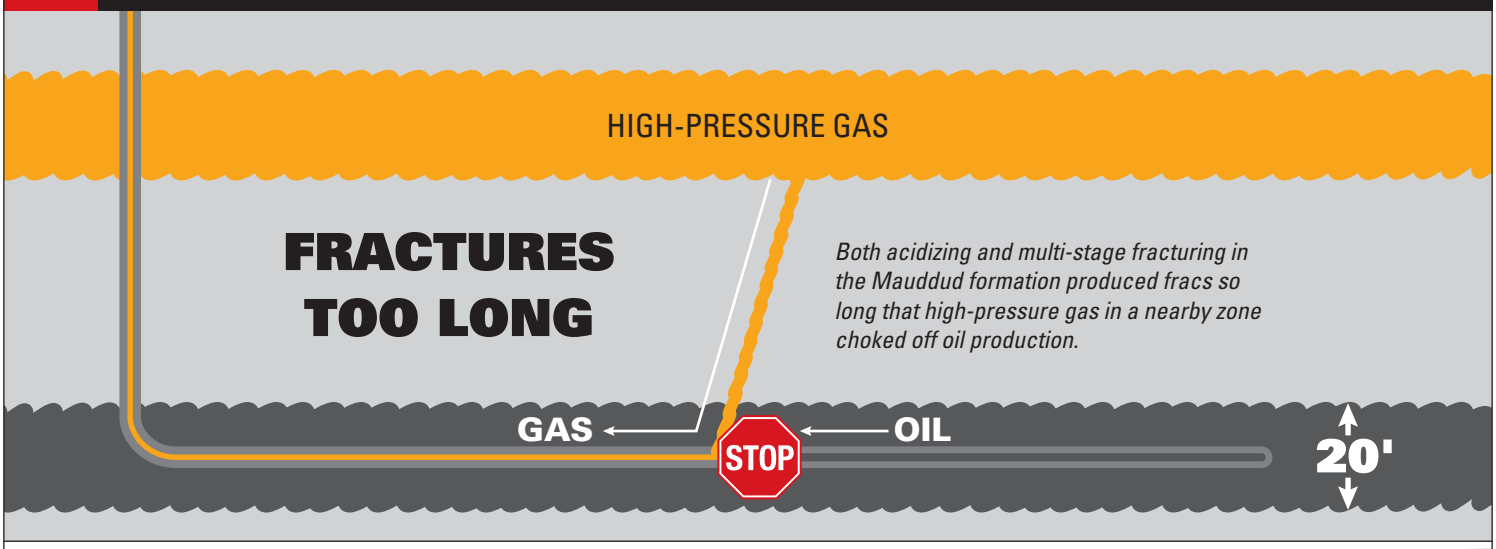
Kuwait Oil Company (KOC) drilled the first horizontal wells targeting the Mauddud Reservoir more than 15 years ago. However, they did not produce for very long. Despite numerous attempts and experiments to restart production of the openhole completions, success proved elusive. Inherent characteristics of the formation, such as a high gas-oil ratio (GOR), make oil production a challenge. In a recent attempt at fracturing with acid that tapped into a high-pressure gas zone, the gas blocked production of the oil that KOC was targeting. After several attempts to solve the puzzle, KOC consulted Halliburton. Halliburton recommended using SurgiFrac® NWB (near wellbore) service with the Hydra-Jet™ SPT tool to create carefully controlled fractures that stayed well within the oil. As of late 2014, Halliburton used this combination to fracture five wells. Sustained production from each well averaged approximately 1,000 BOPD. In each case, new production from the wells paid for the cost of SurgiFrac NWB service in less than a week.



SurgiFrac® NWB service controlled fracture length to stay within reservoir, yet connect natural fracs.

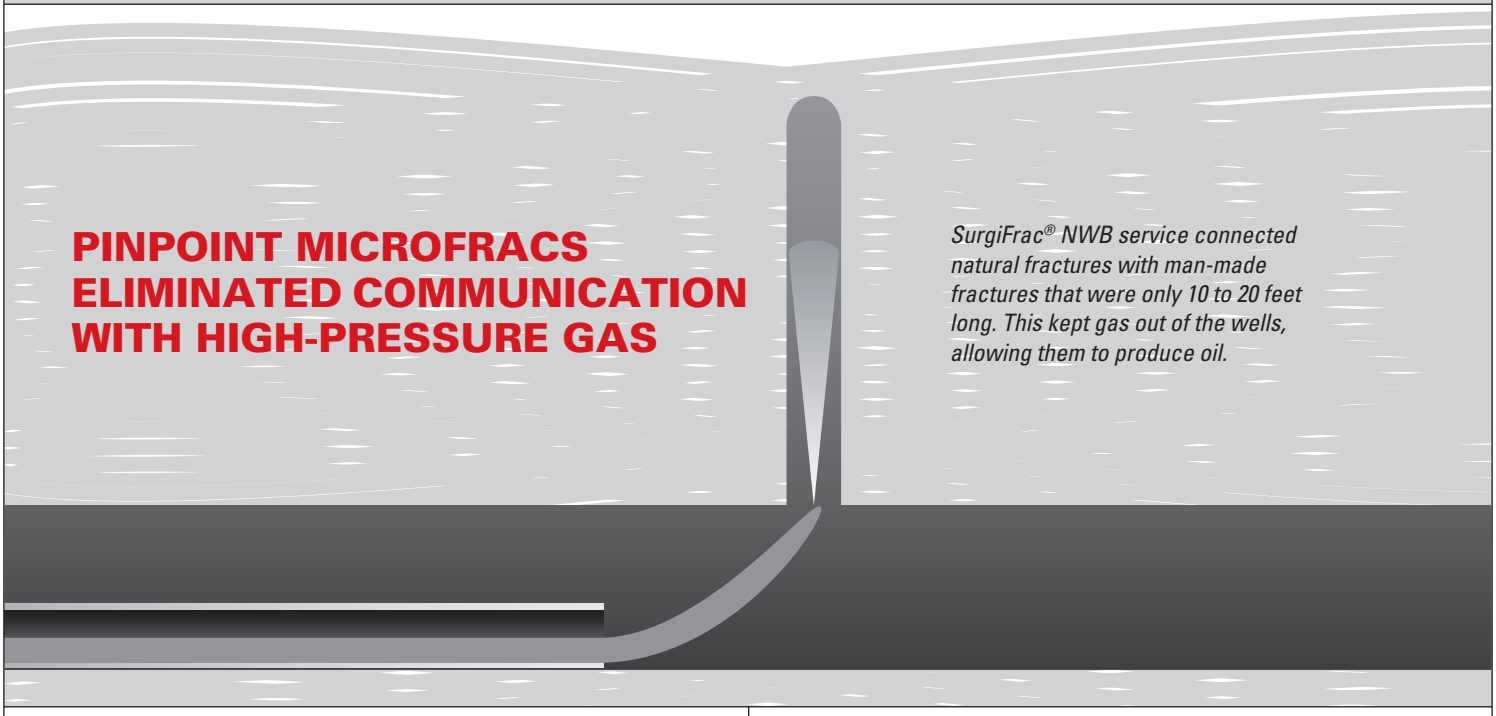
CHALLENGES	SOLUTIONS	RESULTS
Nearby gas Both high-rate matrix acidizing and multi-stage fracturing produced long fractures that communicated with a zone containing high-pressure gas.	**Microfracs** SurgiFrac NWB service enabled engineers to connect natural fractures with precise man-made fractures that did not exceed 20 ft in length.	**Average 1,000 BOPD per well** The unwanted gas production has not choked off high-value oil production. Sustained production from five treated wells averaged 1,000 BOPD.
Prioritizing assets for workovers KOC had so many high-priority wells that low-priority projects – such as those in the Mauddud – could sit idle for years.	**Rigless operation** The technique Halliburton recommended does not require a rig. The tool was deployed through tubing that had a 2.75 in. restriction.	**Ability to address problem wells** This low-cost solution gives KOC the ability to allocate rigs to high-priority projects, yet still address sick wells whenever they choose.
Cost Conventional fracturing techniques cost more than SurgiFrac service and produced only short-term results.	**Higher efficiency** SurgiFrac NWB service saved KOC 10 to 20 percent upfront compared to conventional solutions.	**Quick payback on investment** Halliburton's SurgiFrac NWB service paid for itself with less than a week of oil production.

CASE STUDY



FRACTURES TOO LONG

Both acidizing and multi-stage fracturing in the Mauddud formation produced fracs so long that high-pressure gas in a nearby zone choked off oil production.



PINPOINT MICROFRACS ELIMINATED COMMUNICATION WITH HIGH-PRESSURE GAS

SurgiFrac® NWB service connected natural fractures with man-made fractures that were only 10 to 20 feet long. This kept gas out of the wells, allowing them to produce oil.

AVERAGE 1000 BOPD OF SUSTAINED PRODUCTION

Using this technique on five wells that had not produced any significant amounts of oil for more than 15 years, KOC averaged sustained production of 1,000 BOPD per well.

PAYBACK IN LESS THAN A WEEK

The rigless operation paid for itself in less than a week and allowed KOC to allocate its rigs to higher priority projects.

High pressure gas chokes off oil production

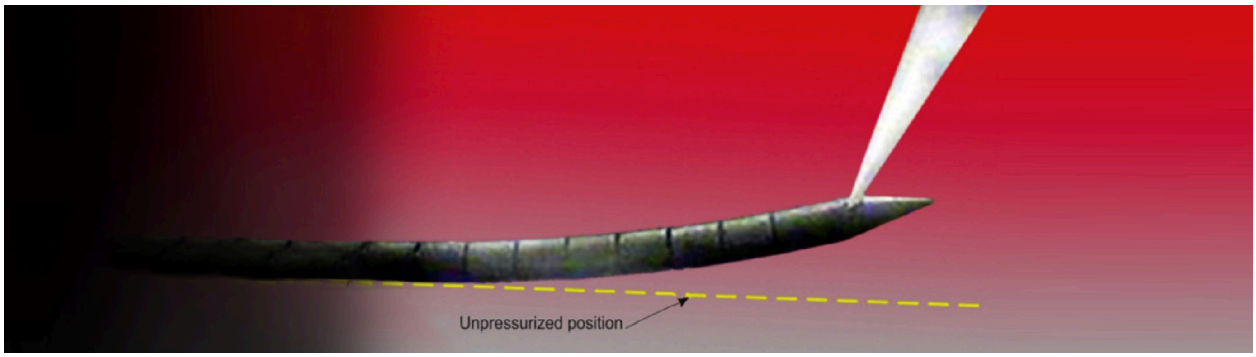
The Mauddud formation in Kuwait has low pressure and tight permeability. All attempts to restart production of the KOC wells through multistage fracturing and high-volume acidizing were short-lived. Wells might flow for a few weeks after the expensive treatments, but would quickly die again. Fractures propagated into an area containing high-pressure gas. Gas then broke through, choking off the flow of more valuable Mauddud oil.

Higher priorities and economics leave oil stranded in place

The challenging reservoir created even more complex completion challenges. The wells proved so difficult and expensive to produce that KOC decided to focus its workover activities on wells with higher economic potential. Despite large volumes of oil still in place, producing it turned out to be difficult and costly.

Halliburton suggests new approach using microfractures

Halliburton felt that the non-producing wells with openhole completions might make excellent candidates for its SurgiFrac® NWB fracturing service. SurgiFrac NWB service uses concentrated, high-pressure fluid jets to create short, highly conductive hydraulic fractures. In this case, Halliburton felt that controlled microfracs could extend through the near-wellbore damage, through undamaged rock, and then connect to a well-developed complex of natural fractures. With careful modelling, Halliburton felt the induced fractures would stay within the Mauddud and *not* break through to nearby gas zones.



The Hydra-Jet™ SPT tool bends under pressure, forcing the tip closer to the rock it is perforating, which increases pressure.

Geometry creates new challenges

Halliburton and KOC then engaged in discussions about deployment of the service. KOC decided not to invest in the cost of a rig to pull tubing. That meant Halliburton had to deploy its tools *through* 3.5 in. tubing that also had a 2.75 in. restriction. However, the hole itself – which was open – had an ID of 8.5 in.

Need to redesign the Hydra-Jet™ tool

Two of these three dimensions created huge challenges. First, none of Halliburton's Hydra-Jet tools would fit through the 2.75 in. restriction. Second, the distance between the jets and the wellbore would decrease the energy that the tool could focus on rock, thus jeopardizing the mission.

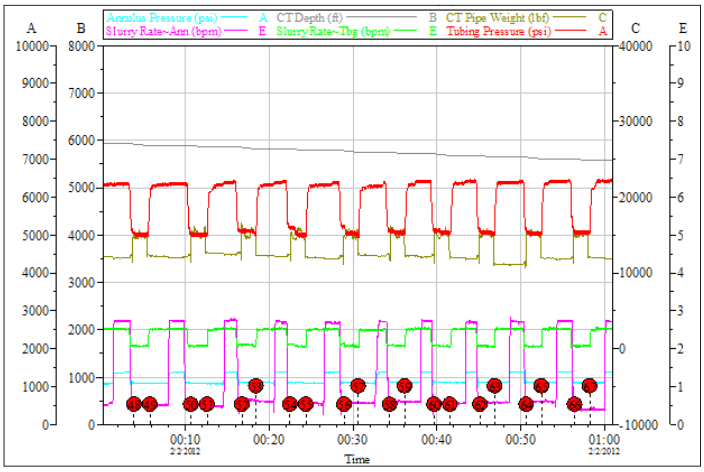
Tool redesign solves restriction problem

To solve the first challenge, Halliburton went back to the drawing boards and completely redesigned a new generation of Hydra-Jet™ tools that could fit through the small restriction in the tubing.

Self-bending nozzle solves distance problem

To solve the second problem, Halliburton also created a special variant of the tool called the SPT (self-positioning tool). The SPT's pressure stream bends the nozzle, decreasing the distance between the jets and wellbore (*see illustration on page 3*).

With the Hydra-Jet™ SPT nozzle touching the wellbore, models showed it could generate enough pressure to create 10 to 20 ft microfractures into the formation – exactly what KOC needed to connect the natural fractures yet avoid breaking through to the high-pressure gas zone. Halliburton used nickel when redesigning the tool because of H_2S in the gas that had previously been encountered.



Graph showing how pressures were maintained with Hydra-Jet SPT to create precise microfractures that stayed within the reservoir.

Low-cost approach: dynamic diversion

All of these changes meant the procedure could be performed in a safer manner by using a coiled-tubing unit instead of a rig, which also helped reduce costs significantly. Also, the Hydra-Jet SPT tool does not require the use of plugs or packers for diversion. It uses "dynamic diversion." Dynamic diversion focuses fluid energy on a single point with enough energy to deeply penetrate rock and enlarge the tunnels it creates. Dynamic diversion also helps ensure that each target interval is treated discretely, receiving only the intended treatment volume and rate. The jetting velocity forces all fluid into the rock despite the 90º turn. Eliminating the need to set plugs or packers cut a two-to-three week job down to less than a day. Finally, because of the large width of the fractures created, no proppant was necessary to hold them open. This saved additional costs.

The "acid test" proves successful

After addressing all the technical challenges, KOC and Halliburton decided to try the technique on one well. The test was a resounding success. Wellhead pressure went from zero to 500 psi. KOC targeted a production rate of 500 BOPD, but initial production *tripled* that; it soared to 1,500 BOPD. Sustained production *doubled* their target; it leveled out at around 1,000 BOPD – for three *years*, not just two or three *weeks*.

One success leads to another – from zero to 1,000 BOPD in five wells

KOC then decided to try the technique on a second well. It too yielded sustained production of around 1,000 BOPD, this time for six months. Since then, three additional wells have been treated. They too are averaging 1,000 BOPD of sustained production – and are still producing. In each well, renewed production paid for the cost of the operation in less than a week.

Potential elsewhere

Halliburton's SurgiFrac service may be beneficial in providing a cost-effective solution for other wells with similar circumstances throughout the Mauddud Reservoir, which extends into neighboring countries.