

# Monterey,

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In an effort to improve oil production at Elk Hills, located in Kern County, California, successful new methods for acidizing both horizontal and vertical Monterey Shale wells were developed. During 1999 and 2000, 21 horizontal Shale wells were drilled with unacceptable production results, even though the petrophysical evaluation indicated the wells should have great flow potential.

The uncemented, slotted liners prevented the use of conventional stimulation techniques. Instead, the acid blend, placement, recovery, and flowback techniques using coiled tubing evolved and improved. Workover equipment optimization and utilization increased and time to market and operating expenses decreased. The results from acidizing horizontal wells increased oil production up to nine-fold.

Due to the successful large-volume hydrofluoric (HF) acid jobs on the horizontal Shale wells, many old vertical Shale wells were acidized using the same technique, increasing average well production by 110 barrels of oil per day (BOPD) and more than 500 MSCF/D. As a result of the diligent, combined team efforts of the operations personnel and the pumping service contractor, the total acidizing costs were reduced by U.S. \$2,300,000. These costs were reduced through blending acid in the field, field-testing the oil for additives, lowering spent acid disposal costs, and mixing acid on the fly.

## **Field History**

NA Shale drilling began in the fall of 1999 with two horizontal wells placed in the N Shale and two horizontal wells placed in the A Shale. The wells were re-drills of existing vertical wells with 7-in. production casing cemented in place. The wells were kicked off above the zone of interest with build rates above 20°/100 ft using a 6 1/8-in. bit. The laterals were drilled with high-viscosity drill-in fluids (DIF), with 6% KCl water as a base fluid and a cost of approximately U.S. \$60 per barrel. Calcium carbonate (CC) was used for fluid-loss additive (FLA). The expectation was that the wells would flow to the tank batteries at economical rates. Therefore, 3 1/2-in. slotted liners were run to total depth. External casing packers were used only to isolate fluid above the zone of interest.

One mud company suggested that only a few gallons per foot of HCl acid would be necessary to dissolve the CC FLA. A second mud company stated that only a 50-psi differential into the wellbore would be necessary to recover the CC FLA. The first well was initially acidized with 2.5 gal of 17% HCl per foot of net pay (gpnf) through coiled tubing (CT). Nitrogen and CT were used to recover the spent acid.

The first A Shale well would not flow. A 1 1/2-in. rod pump was initially installed, but was increased to a 2-in. plunger diameter after a fluid level shot indicated 4,288 ft of fluid above the pump. The relatively high build rates and small liner size prevented the rod

pump from being set as deep as necessary to maximize the pressure drawdown. Production, however, increased from 9 BOPD + 69 MSCF/D (1 1/2-in. pump) to 303 BOPD + 1,650 MSCF/D (2-in. pump) in two months.

In an attempt to increase production, the acid volume was increased to 28.1 gpnf of 17% HCl through the next three wells (two N Shales and one A Shale). The last well was foamed with nitrogen for diversion. Nitrogen and CT were used on all three wells to recover the spent acid. Beam pumping units (BPU) were installed on all three wells within two months of their initial completions to reduce the producing bottomhole pressure (BHP) and increase production rates. The third well was reacidized with 11.0 gpnf of 13.5-1.5% acid (foamed), but oil production decreased from 105 BOPD + 253 MSCF/D to 26 BOPD + 382 MSCF/D after being killed with produced water. The wells initially averaged 107 BOPD + 708 MSCF/D, declining to 33 BOPD + 533 MSCF/D in two months.

Horizontal redrilling of existing vertical wells continued into 2000 with two more N Shale laterals and four more A Shale laterals using DIF for mud. With the same completion technique, the six wells initially averaged 244 BOPD + 628 MSCF/D, declining to 70 BOPD + 311 MSCF/D in two months.