



# ADVANCED TECHNOLOGIES FOR MANAGING PRODUCED WATER

## BOTTOM LINE

Technologies are available to prevent the surface production of water, as well as the subsequent treatment and disposal of water, which can be an expensive process.

## PROBLEM ADDRESSED

Water production, a common factor in most wells, can make or break a project's performance—by reducing the flow rate or ultimate recovery, or by raising costs. This water must be treated, removed, and disposed. Water re-injection disposal costs are \$0.25 to \$0.50 per barrel and, if it must be trucked, costs can rise to \$1.50 per barrel.

## KEY WORDS:

Water Production  
Injection  
Polymer Gel Treatments  
Downhole Water Separation

## TECHNOLOGY OVERVIEW

Produced water can be related to the reservoir, such as with coning and channeling (particularly in waterfloods). Alternatively, it can be related to completion problems, including: casing leaks, cement channels, barrier breakdowns, or misdirected wells in high water zones. Technologies exist for keeping produced water from reaching the surface, thus lowering costs and avoiding environmental problems. Polymer gels cut water production by blocking fluids from the wellbore, or by improving sweep efficiency. Dual-completion water sinks, which individually produce the oil and water legs, reduce differential pressure, and reduce coning in dual-action pumping systems, lowering treating costs as they separate the oil from the water downhole, and then re-inject it.

### **Application Insights**

Traditional approaches are to avoid well completions in zones which may produce high water, control production to minimize coning, and squeeze high water-cut zones. In addition, gel treatments function as blocking agents, shutting-off water zones or reducing fracture communication. Success with gel treatments relies on selecting wells that

have high water-oil ratios, large amounts of unproductive water output, substantial moveable oil saturations, unexpectedly low oil recoveries, early water or gas breakthroughs, or high fluid levels in the wellbore.

Dual-completion water sinks are perforated in both the oil and water legs of a formation, which produce simultaneously with rates controlling pressure differentials/coning. When properly balanced, the oil zone produces essentially water-free oil, while the water zone produces essentially oil-free water. Although water is still produced to the surface, separation costs are lowered. A low-tech variation injects the produced water into another formation that is not in pressure communication with the producing formation. The disposal zone must have adequate injectivity to handle anticipated fluid volumes, and thus requires more perforations and larger tubulars.

Dual-action pumping systems use a rod pump to produce oil or gas and water from the annulus on the upstroke, while injecting water on the downstroke using gravity segregation. The majority of the waste water is never brought to the surface. A modified mechanical lift pump displaces large quantities of unwanted water either below or above the producing formation.

## LESSONS LEARNED

Successful polymer gel treatments depend on correctly identifying the problem (coning, breakthrough, or permeability streaks), and the type of gel fluid chosen (according to temperature, salinity, or fluid compatibility), as well as treatment sizing, placement, and application.

Dual-completion water sinks are applicable in formations where the oil and water legs are in good pressure communication. The operator must know porosity and permeability relationships, to understand how fluids will flow. Careful planning is required to size the perforations and

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### **SPEAKERS:**

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*Dual Action Pumping System:*

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*Downhole Water Sink:*

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tubing, which will cause the reduction in water leg pressure to exceed the drop in oil leg pressure.

Since less fluids are lifted with dual-action pumping systems (18 to 30% of original volumes), energy costs are reduced. Even though the process requires two rod pumps, only one rod and tubing string are needed. The weight of the rod string and the fluid in the tubing provides the pressure for injection. Care must be taken not to place the rod string in compression, and to adjust pump-stroke timing to ensure gravity separation.

## FIELD RESULTS

Amoco used gel treatments at the Wertz Field CO<sub>2</sub> WAG flood in 10 injection wells, reducing gas-to-oil and water-to-oil ratios and increasing production from 100 to 300 barrels of oil per day (bopd) per pattern. Overall, Marathon performed 108 gel treatments, shutting off 236,000 barrels of water per day (bwpd) and increasing oil production by 3,000 bopd. ARCO/BP Amoco performed 37 gel treatments in 31 Prudhoe Bay wells, resulting in a one-month increase of 22,000 bopd and a concomitant gas rate reduction of 213 million cubic feet per day.

Dual-completion water sinks in the Nebo Hemphill Field in Louisiana reduced produced water cuts to negligible levels (0.1%), while oil production increased from 30-40 bopd to 50-60 bopd. Dual-action pumping systems were tested in at least 12 fields through mid-1997. On average, oil production increased 42% while water production decreased 74%. Some fields experienced only modest gains in oil output, but the drop in water production was always significant.

## Economic Implications

Injection-side gel treatments in Wyoming's Big Horn Basin increased oil production by 3.65 million barrels. The average treatment was 215,000 barrels at a cost of \$45,200. The average cost of incremental oil was \$0.21 per barrel. Amoco's CO<sub>2</sub> WAG flood gel treatments increased reserves by 735,000 barrels at a cost of \$1.31 per barrel. Payout was three months, and the economic life of marginal wells was extended by almost two years.

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Dual-completion water sinks have shown payouts matching conventional completions. Oil rates can be up to three times the rates seen in conventional wells, with net monthly earnings five times higher.

Although dual-action pumping systems improve hydrocarbon production, economics are most improved by avoiding water handling costs. Revenue from a field in Seward County, Kansas, were \$5,479. Water handling costs were \$2,013. After installing dual-action pumping systems, revenue increased to \$7,274, while water handling costs dropped to zero. A similar case in Texas County, Oklahoma, doubled monthly revenue to \$9,000.

## CONNECTIONS:

### **Dual-action pumping systems**

*Dresser Oil Tools*

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