Resin Treatments Enhance Production

By Brent Thomas
and William J. Heaven

CALGARY, ALBERTA, CANADA–The cost of unwanted water production from oil and gas wells is constantly increasing. With the industry spending millions of dollars worldwide each year handling, treating and disposing of produced water, it is no surprise that operators are paying more attention to technology that can minimize those costs.

One such technology is resin treatments, which are being applied both to reduce water production and control gas leaks and migration in well bores. Resin treatments use a very low molecular weight monomer that produces a rigid compound. The low molecular weight provides low viscosity at injection, which in turn, allows treatments to invade into even the tightest zones.

Many factors contribute to high water-cut production, including water flow through fractures, high-permeability streaks, and water coning. Poor cement integrity surrounding the well bore is another common problem that often results in excessive water production. Because the characteristics of the problems are so diverse, successful treatment often requires the ability to manipulate injection viscosity, setup time, and in some cases, density.

Although several types of cements have been developed to help resolve gas migration problems within a well bore, many have proved ineffective because of their tendency to bridge and prevent cement particles from penetrating into the matrix. Resin technology has proven very effective at isolating gas leaks and gas migration problems.

Depending on the source of water production, the ideal treatment can take many forms. Viscosity is usually the most important parameter in designing a treatment. Placing and pumping low-viscosity treatment fluids with high mobility allows resins to invade the zones of highest water saturation while maintaining the productive capacity of hydrocarbon zones.

The technique used to place the treatment is also important, and treatment volume can greatly impact efficiency. Water production is often associated with a hydraulic fracture that has extended out of the hydrocarbon zone and into a high water-saturation zone. In these cases, it is necessary to maintain the effectiveness of fracture near the well bore to keep production at economic rates while shutting off the water-producing portion of the fracture. Designing a proper treatment with the precise volume needed to accomplish this objective can be difficult. In such cases, the fluids used to overdisplace the treatment play as important of a role as does the chemistry of the treatment itself.

FIGURE 1

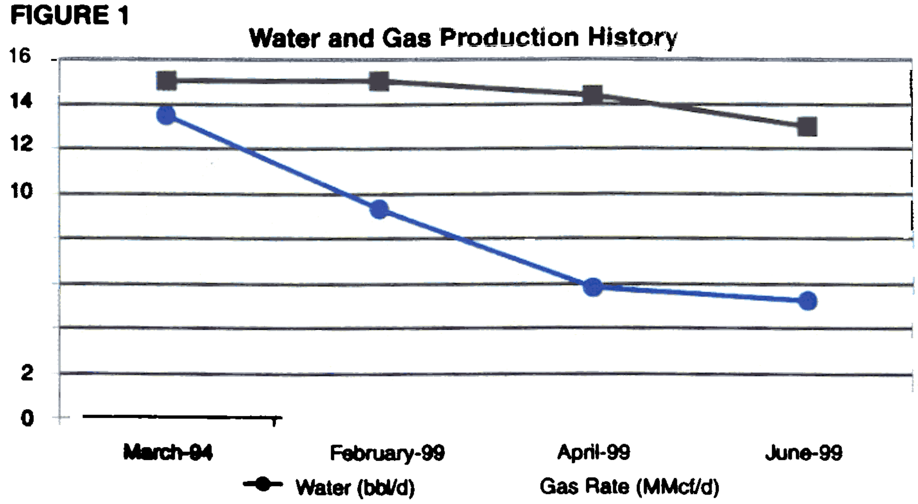
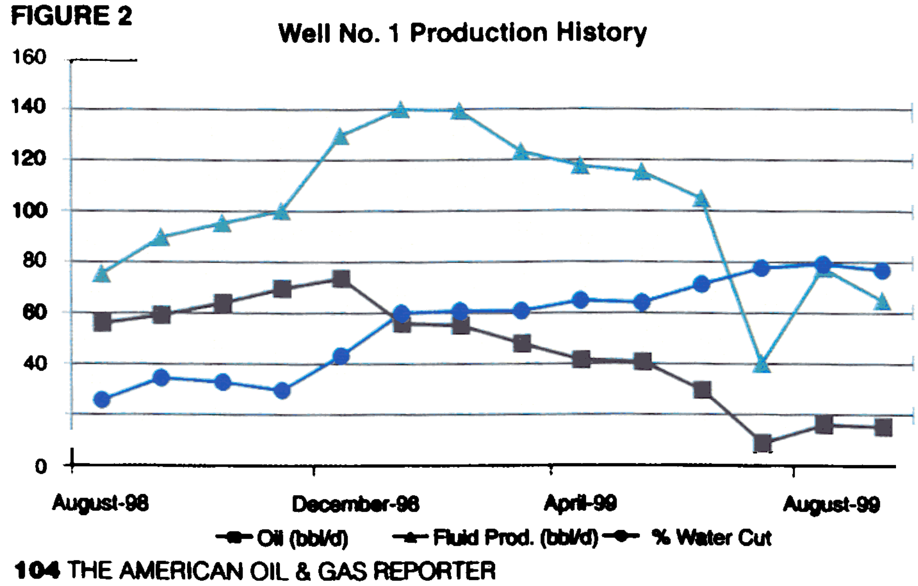


FIGURE 2



Water Shut-Off Applications

Resin treatments have successfully minimized water production and shut off gas leaks in well bores in producing oil and gas wells in numerous applications. In one water shut-off application, a well had been drilled into a very tight formation. Gas permeability was 5 milliDarcies, making the well's flow rate uneconomic. The well was subsequently fractured using gelled frac oil, but post-frac production averaged 110 barrels of water per MMcf of gas. Given the high water-to-gas ratio, the well remained uneconomic.

A resin treatment was then designed on the basis of the fracture size. The completion interval was at 3,300 feet, so it was important to design the overdisplacement strategy appropriately. Sufficient fluid had to displace the resin into the end of the fracture while keeping the near-well bore area clear. A fluid control valve or cement retainer can control overdisplacement volumes, but using either would add significantly to treatment cost. The operator ultimately elected to use nitrogen to decrease fluid control costs and minimize overdisplacement propensity from hydrostatic head. Moreover, nitrogen allowed precautionary measures to be taken so that any aqueous phase in the well bore region would not present phase interference, and to minimize the threshold pressure required to establish high gas rates after resin treatment.

Figure 1 shows the results of this application. Before treatment, the daily gas flow rate was 0.5 MMcf with more than 220 barrels of water. Although the gas rate remained in the same range after treatment, water production was reduced by a factor of seven. In fact, 90 days after treatment, the water-to-gas ratio had been reduced to 71 bbls per MMcf. For this kind of well, water shut-off technology may be the only alternative. The most important factor, of course, is the economics. For this well, the resin treatment cost $12,000 and the daily net back averaged $800 a day–a payout of 15 days.

Figures 2, 3 and 4 display oil, gas and water production from three wells drilled into the same formation. Figures 2 and 3 show that water breakthrough occurred shortly after production commenced in the first two wells. As a precautionary measure, the operator decided to inject a low-viscosity, short-setup time (1.5 hour) resin treatment into the oil/water contact in the third well after it was drilled. As Figure 4 depicts, the subsequent four months of production from Well No. 3 were completely free of water.

Water shut-off technology is often considered a "last resort" for older wells that begin experiencing water production problems. But as this example illustrates, placing a treatment early in the life of a producing well can solve water influx problems more easily and at less cost, and prove more effective.

In a third application, four oil wells had been drilled into the same producing formation. Natural fracturing was thought to be the major contributor to three of the wells' high production rates. However, one well that had been drilled to exactly the same depth and completed in the same formation performed poorly (excessive water and very low oil production). The operator decided to inject a very low-viscosity resin treatment to preferentially invade the water-saturated zones and reduce water while minimizing water phase interference to the oil zones. Figure 5 shows the well's production after treatment and Figure 6 shows well revenues at an oil price of both $12 and $20/bbl.

Gas Migration Applications

Holes in casing, surface casing vent flows and poor well bore integrity contribute to fugitive gas leaks. Resin technology has proven very effective at completely blocking gas leaks in almost every type of well.

One well exhibited problems associated with two intervals (the first was from 1,640 to 1,686 feet, and the second was 3.3 feet thick at 1,980 feet) that had remained even after several cement intervention squeeze procedures. The first interval was allowing gas to migrate to surface some 330 feet from the well, while the lower interval exhibited rust holes in the casing that resulted in surface casing vent flow. Both intervals exhibited very low bleed-off rates (30 psi in 10 minutes when pressurized to 1,000 psi).

The treatment was simple: A balanced

FIGURE 3

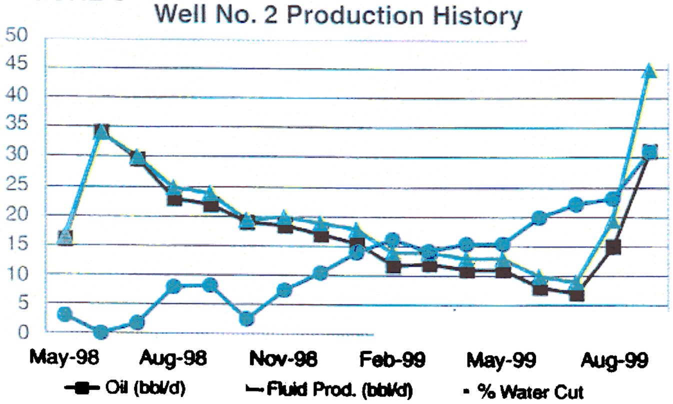


FIGURE 4

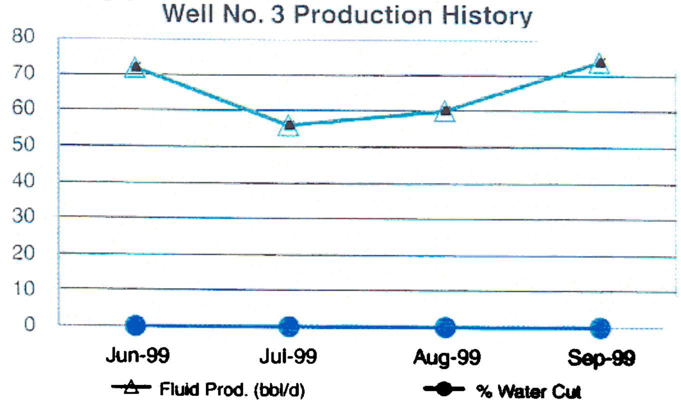


FIGURE 5

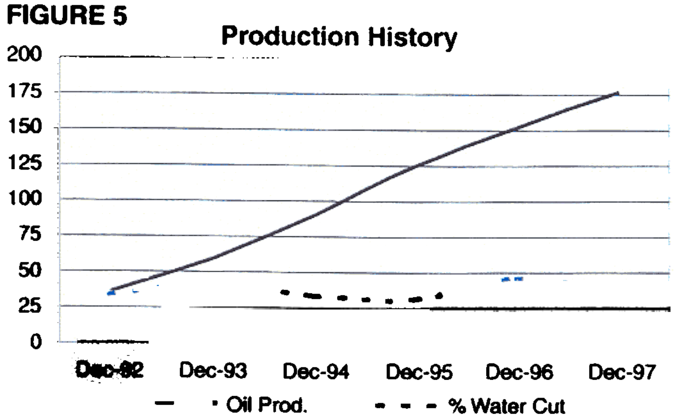
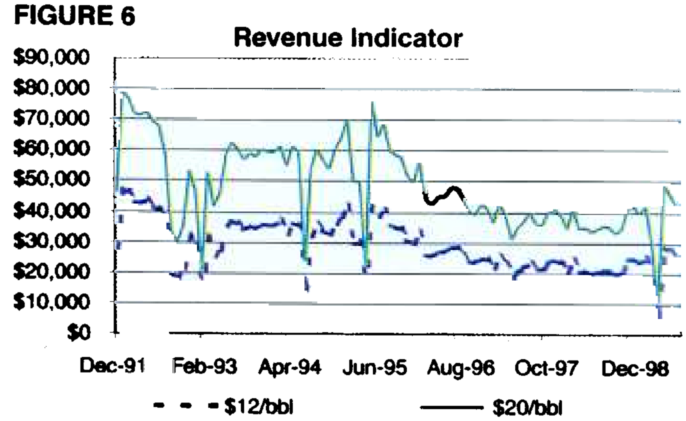


FIGURE 6



resin plug was used to block each interval. After the plug was spotted, a constant pressure of 1,000 psi was applied to force

tion, surface casing vent flow had been measured at 150 Mcf/d at 162 psi shut-in pressure. In order to evaluate the source of the gas flow, two temperature/noise log combinations were run in the casing to a depth of 1,485 feet. The first run was made with the surface vent closed to establish a base run. The surface casing vent was then opened and allowed to flow for 12 hours. Comparing the two runs showed significant gas flow from a shallow zone (997 feet depth).

To shut the flow off, a low-viscosity resin treatment was pumped down the surface casing and into the flow channel.

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the resin to bleed into the formation. The following day, the residual resin was removed from the well bore using wax

After the treatment was spotted and pressured to 348 psi, resin was injected into the formation with a final buildup pressure of 435 psi on the well bore. The well was shut in overnight, and surface casing pressure was negligible the next morning. Several years later, there is still no evidence of surface casing vent flow.

Unwanted water production and gas leaks are serious problems. Fortunately, resin treatments have proven highly ef-

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scrapers, and gas migration and surface casing vent flow were completely shut off.

In another gas leak shut-off applica-

fective at enhancing production by decreasing water-to-oil ratios and improving production well integrity in a variety of applications. ❒

Editor's Note: The preceding article was adapted from a presentation at the Petroleum Network Education Conferences' 1999 International Conference on Reservoir Conformance Profile Control, Water and Gas Shut-Off, held Nov. 8-10 in Houston.

Coming In March

Coalbed methane is making headlines all over the country. *The American Oil & Gas Reporter's* annual Gas Processing & Treating special report takes a look at how small independents are exploiting the trend, and what technologies can help better produce and process coalbed methane. We also explore the economics of wellhead gas processing, present new nitrogen rejection and glycol dehydration technologies, and discuss the advantages of outsourcing gas compression.