A Polymeric Treatment to Decrease Water Production in Low Pressure Gas Wells

Larry Eoff, Mary McGowen, Mauricio Gutierrez, Dwyann Dalrymple, Julio Vasquez
Halliburton; and Emile Barrett, Santos
Agenda

• Introduction
  – Polymer chemistry
  – Laboratory testing
• Case Histories
• Alternate Polymer Usage
Bullhead Polymer System

- A water-soluble polymer
- Hydrophobic modification imparts unique associative properties (Increased adsorption)
- Reduces permeability to water much more than to gas or oil
Permeability Modification for Oil and Water Saturated Cores

- Permeability to oil increased by 7%
- Permeability to water decreased by 98%
Permeability Modification for Gas and Water Saturated Cores

- Gas core
- Water core

**Permeability (mD)**

<table>
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<tr>
<th>Initial Perm</th>
<th>Final Perm</th>
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<tbody>
<tr>
<td>0.6</td>
<td>0.5</td>
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<tr>
<td>0.5</td>
<td>0.4</td>
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<tr>
<td>0.4</td>
<td>0.3</td>
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<td>0.3</td>
<td>0.2</td>
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Lab Data
General Candidate Well Criteria

- Layered formation
- Sandstone or carbonate formation
- Bottom hole static temperature (BHST) up to 325°F
- Economically viable: sufficient remaining reserves
- Meets temperature/permeability criteria:
Gas Wells In Central Australia

- Layered formations: highly laminated sandstones with interspersed coals and shales.
- Most wells have BHST 250 to 370 °F
- Perforated, and often Fracture Stimulated
RPM Treatment of Gas Well in Cooper Basin, SA

- Well struggled to kick off after shut-in
  - At risk of not coming back after shut-ins
- Estimated 1.5 BCF remaining reserves at risk

Pre-Treatment PLT Data

6219’ – 6254’
6500’ – 6504’
6554’ – 6558’
6598’ – 6604’
6636’ – 6709’
6724’ – 6758’
6752’ – 6864’

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51.2 MSCF Gas, 4.7 BWPD
273 MSCF Gas, 237 BWPD
972 MSCF Gas, ~400 BWPD

>300 BWPD leaking up through Cement plug/retainer and no gas

Water level at 6630’

Hydraulic Fracture
Treatment Design

- Treatment Concentration:
  - BHT = 252 °F
  - Ave. Perm. In lower interval ~50 mD (0.1 to 100 mD)

- Treatment Volume:
  - Based on well criteria: 500 bbl treatment

- Overdisplace: N₂
  - Limit liquid injection
  - Reduce cleanup time
  - Contact matrix gas
Results (1)

- Initial gas = 0.32 MMscf/Day
- Final gas = 2.23 MMscf/Day (6-fold increase)
- Treatment cleaned up within days (often gas wells can take months, if overflushed with water)
Results (2)

- Water column dropped at least 70 feet (below HUD).
- Frac below HUD:
  - Water rate cut by ~50%
  - Now able to produce gas.
Case 1 Production History Prior to Treatment

Axis 1
Free Gas MMscfd

Axis 2
Water BPD
Job Procedure

- Clean out sand with coiled tubing and nitrogen foam
- 10 bbl 7% KCl preflush to establish injectivity
- 50 bbl treatment
- 29 bbl overflush
- POOH with coiled tubing and lift well with injection of 62 Mcf of gas
Results

Case 1 Production After RPM Treatment

- **Gas Production, MSCFD**
  - 0
  - 100
  - 200
  - 300
  - 400
  - 500
  - 600
  - 700

- **Water Production, BWPD**
  - 0

- **Time**
  - 1-Aug-04
  - 17-Feb-05
  - 5-Sep-05
  - 24-Mar-06
  - 10-Oct-06

- **Graph Legend**
  - Red line: Gas
  - Blue line: Water
Columbia Gas Well #2

- Well shut in for one year, high water production had led to drastic decline in gas production
- Similar treatment sequence to well #1
Results

Case 2
Initial Well Production Post Treatment (Every 2HRS)

Gas-Water Mscfd-BPD

> Gas (Mpcd)  Water (bpd)  Cond (bpd)
Overall Treatment Results to Date

- Over 200 treatments have been pumped world wide in both gas and oil wells
- Success rate in gas wells has been 80%, based on increase in gas production and/or decrease in water production
• This chemistry is also used in other applications
  – Fracturing close to water zones
  – Acid diversion
• To date over 1100 jobs have been performed
Brown sandstone at $S_{or}$, 200 °F (93 °C), 6000 ppm Polymer, 500 mL treatment, followed by 25 mL oxidizer
Questions?