Baker Petrolite

Modeling Expertise Takes Uncertainty out of Multi-Zone $BaSO_4$ Scale Squeeze Lifetimes

Benefits

- Lower risk of scale blockage in a field with multiple production zones
- Better squeeze planning
- Optimized treatment costs without sacrificing confidence in downhole scale protection
- Full service advanced scale control

Challenges

- North Sea wells with multiple production zones
- Aggressive barite scaling in the perforated interval
- Different scale squeeze lifetimes for each production zone
- Increased confidence in the scale program was needed

Baker Hughes Solution and Results

- Advanced modeling studies to ensure all zones remain protected
- Scale inhibitor selection testing targeting:
  - Proven performance against $BaSO_4$ scale
  - Compatibility with the formation rock and brine
  - Thermal stability
  - Adequate retention in the formation
- Customized squeeze treatment
- Program monitoring and verification

Maximize excellence in practice

A customer operating in the North Sea had numerous wells with water production from multiple production zones. While the zones all have similar porosity and permeability, pressure differences caused production heterogeneity from the zones. Produced water has high barium content and is prone to aggressive scaling. Scale squeezes are a preferred method to control barite deposition in the perforated interval and had been used successfully in this field. However, zonal heterogeneity meant squeeze placement was non-uniform, resulting in different squeeze lifetimes for each zone. This led to the risk of having some producing zones fall below the minimum inhibitor concentration (MIC) despite surface tests showing returns remaining above the MIC. The customer sought help from Baker Hughes to determine appropriate scale squeeze treatment schedules that would ensure all zones remain at or above the MIC.

Baker Hughes personnel worked closely with the customer to carry out a squeeze modeling study. The most challenging well in the field was selected for initial work. The well produced from a sandstone reservoir with low clay content, and had an average porosity of 30% and average permeability of 3 darcy. The well featured a 1429 foot horizontal interval producing over 12,500 BWPD from 9 zones. By simple calculation, to ensure a 1 year squeeze treatment life, in excess of 4.5 million barrels of water would need to be protected.

To address the challenge of protecting all producing zones, the well was modeled as a 9 layer interval in the software. Injection and production data was supplied by the operator's reservoir department, and inhibitor-rock isotherm parameters were derived from a neighboring well. Successive iterations (cf. Figure 1) revealed that beyond 3.5 million barrels of water production at least one zone could fall below the MIC and begin to suffer scale deposition. That translates to an actual effective squeeze lifetime 23 percent shorter than anticipated by simple volumetric calculation. The operator would risk scale damage in some zones for as much as three months of a one year program, even though the composite inhibitor returns to the surface could remain well above the MIC.

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The well was squeezed using 2406 bbl of 20% BAKER PETROLITE SCW82361 Inhibitor as the main treatment overflushed with 20,000 bbl of injection-quality sea water in a design to protect 3.5 million barrels of water.

The squeeze treatment afforded outstanding scale production on this well. Analyzed product returns were found to conform closely to that predicted by the model (illustrated in Figure 2). In excess of 4 million barrels of water were produced before the well was re-squeezed, by which time the 3.5 million bbls design had been exceeded and the prediction was that three zones would be depleted. However, ion analyses indicated no scaling activity in the well at the 13 month point.

As a result of the enhanced confidence gained in working with Baker Hughes, the customer opted to treat ten similar wells. All wells have now been successfully treated for minimally 1 year protection with water volumes ranging from 1 to 5 million barrels.

This case history is presented for illustration purposes only as results may vary between applications.

The blue "bar chart" graphic represents the nine separate producing intervals. The green-yellow-red coloured bars illustrate whether a producing interval is above MIC (green), at MIC (yellow) or below MIC (red) at the endpoint of the simulation. The black line plot represents the predicted scale inhibitor return profile.

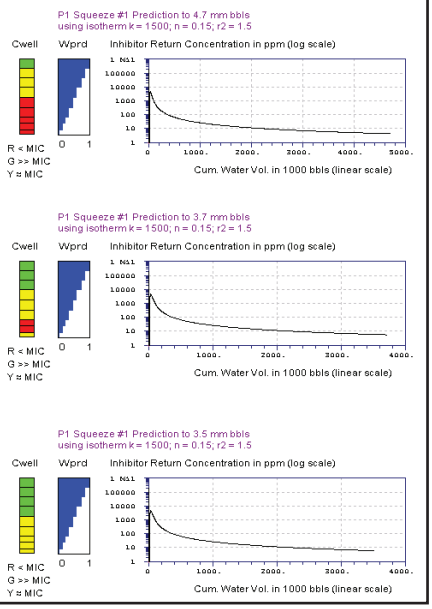

Figure 1

Analyzed product returns (purple points) were found to conform closely to that predicted by the 9-interval model. At the end of the monitoring period, three zones were predicted to be below the MIC.

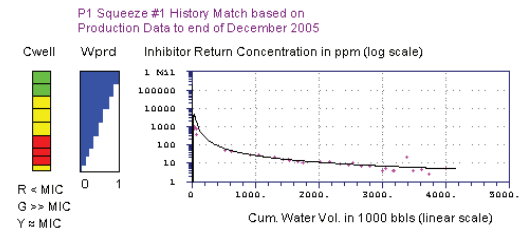

Figure 2

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