Anadarko’s West Texas Chemical Program: Optimizing Chemical Usage & Injection Points

Amjad Abdelrahman
Amber Helm

Production Chemicals Optimization Congress
June 29-30, 2016
Outline

- Area and System Overview
- Flow Assurance Challenges
- Chemical Treatments
- Optimization of Injection Points
- Data Management and Chemical Selection
- Monitoring and Injection Control
- Concluding Remarks
Anadarko’s West Texas Overview

- **Geographic Overview**
  - Delaware Basin – Texas Portion
    - Loving, Reeves and Ward Counties
  - >600,000 gross acres

- **Geologic Overview**
  - Historically targeted the deep Pennsylvanian gas reservoirs (Strawn, Atoka and Morrow) at +15,000’ TVD
  - Main Target Formations:
    - Avalon Shale
    - Bone Spring Sand
    - Wolfcamp Shale
  - Average Depths: 8,000’ – 12,000’ TVD

- **Flow Assurance Challenges**
  - Paraffin – Mainly at Surface
  - Corrosion – Bacteria & Under Deposit
  - Scale – CaCO3, BaSO4 and FeS
  - Hydrates – High Pressure Lines
### Production System Overview

- **Flow assurance:** “ensuring successful and economical flow of hydrocarbon stream from the reservoir to the point of sale.”
  - Pressure and temperature effects on flow assurance: scale, paraffin, corrosion and hydrates

- **Know your system, process flow, fluid properties and scale & corrosion tendencies**
  - How does production processing affect flow assurance at surface?

- **Artificial lift and well life cycle**
  - How does artificial lift drawdown affect downhole conditions and flow assurance?
  - ESP / rod pump / gas lift / plunger lift
Reservoir Fluid Properties

- **Avalon Shale**
  - High CO2; tubing is coated for protection from CO2 corrosion
  - Tendencies to form CaCO3 scale downhole and at surface

- **Bone Spring Sand**
  - Corrosion and solids issues related to bacteria and the formation of FeS
  - CaCO3 scale as pressures decrease (especially downhole where temperature is relatively high)

- **Wolfcamp Shale**
  - Corrosion and solids issues related to bacteria and the formation of FeS
  - CaCO3 scale as pressures decrease (especially downhole where temperature is relatively high)
  - BaSO4 scale in areas where barium content is high (western portion of the field)

### Water Properties

<table>
<thead>
<tr>
<th></th>
<th>Avalon Shale</th>
<th>Bone Spring Sand</th>
<th>Wolfcamp Shale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>1.11</td>
<td>1.03</td>
<td>1.03</td>
</tr>
<tr>
<td>pH</td>
<td>6.65</td>
<td>6.98</td>
<td>7.28</td>
</tr>
<tr>
<td>TDS</td>
<td>175,000</td>
<td>40,000</td>
<td>35,000</td>
</tr>
<tr>
<td>Na+ (mg per l)</td>
<td>58,000</td>
<td>14,000</td>
<td>13,000</td>
</tr>
<tr>
<td>Cl- (mg per l)</td>
<td>105,000</td>
<td>23,000</td>
<td>21,000</td>
</tr>
<tr>
<td>Ca++ (mg per l)</td>
<td>5,400</td>
<td>490</td>
<td>390</td>
</tr>
<tr>
<td>Ba++ (mg per l)</td>
<td>7</td>
<td>1</td>
<td>10</td>
</tr>
<tr>
<td>Fe (mg per l)</td>
<td>55</td>
<td>35</td>
<td>20</td>
</tr>
<tr>
<td>Mn++ (mg per l)</td>
<td>2</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>SO4- (mg per l)</td>
<td>1,500</td>
<td>760</td>
<td>510</td>
</tr>
<tr>
<td>HCO3- (mg per l)</td>
<td>2,175</td>
<td>490</td>
<td>610</td>
</tr>
<tr>
<td>CO2 (mg per l)</td>
<td>600</td>
<td>120</td>
<td>150</td>
</tr>
</tbody>
</table>

### Oil Properties

<table>
<thead>
<tr>
<th></th>
<th>Avalon Shale</th>
<th>Bone Spring Sand</th>
<th>Wolfcamp Shale</th>
</tr>
</thead>
<tbody>
<tr>
<td>API Gravity</td>
<td>50 - 60</td>
<td>42 - 48</td>
<td>42 - 48</td>
</tr>
<tr>
<td>Specific Gravity</td>
<td>0.74 - 0.78</td>
<td>0.78 - 0.82</td>
<td>0.78 - 0.82</td>
</tr>
<tr>
<td>Cloud Point (°F)</td>
<td>80 - 100</td>
<td>65 - 120</td>
<td>65 - 120</td>
</tr>
</tbody>
</table>

### Gas Properties

<table>
<thead>
<tr>
<th></th>
<th>Avalon Shale</th>
<th>Bone Spring Sand</th>
<th>Wolfcamp Shale</th>
</tr>
</thead>
<tbody>
<tr>
<td>Specific Gravity</td>
<td>0.85</td>
<td>0.78</td>
<td>0.78</td>
</tr>
<tr>
<td>BTU Content</td>
<td>1,200</td>
<td>1,400</td>
<td>1,400</td>
</tr>
<tr>
<td>CO2 Content</td>
<td>12%</td>
<td>0%</td>
<td>0%</td>
</tr>
</tbody>
</table>
Scale & Corrosion Modeling

- Engineering Technology group utilizing simulation programs to predict scaling tendencies and corrosion rates in the production system
- Injection points are selected based on simulated results
- Example: modeling for a well with high Calcium, Bicarbonate & Sulfate levels

CaCO₃ scale at low pressures & high temperatures

High corrosion rate at high pressures & high temperatures
Chemical Treatments in the Production System

- Downhole & surface treatment is needed to combat flow assurance issues

- Start with treating anything that is injected into the formation
  - Completion Operations
  - Workover Operations

- Treat other system components as necessary
  - Artificial Lift Downhole Treatment – Scale and Corrosion
  - Surface Production Operations Treatment – Scale, Corrosion and Paraffin
  - Pipeline & Central Facilities Treatments - Scale, Corrosion and Paraffin
  - Water Disposal Treatments – Scale and Corrosion
Completion and Workover Chemical Treatment

- All fluids injected into the wellbore should be properly treated to avoid souring the reservoir

**Completion / Stimulation Operations**
- Source water selection and treatment
- Compatibility of stimulation fluids with reservoir fluids
- Biocide treatment for bacterial control
  - H2S issues if bacteria growth is not prevented
- Scale treatment for potential scale issues
  - BaSO4 scale if formation contains high Ba and water is contaminated with SO4

**Workover Operations**
- 10 ppg brine typically used as kill fluid
- Treated at surface prior to pumping into wellbore with the following:
  - Biocide for bacterial control
  - Corrosion inhibitor for corrosion control
  - Scale inhibitor for scale control
- Treatment loading varies from 0.25 to 0.50 gpt
- Chemicals mixed in frac tanks after loading tanks with brine

**Packer Fluids**
- Long-lasting chemicals for downhole tubular protection
Artificial Lift Chemical Treatment – Rod Pump

- **Downhole treatment**
  - Downhole temperature higher than cloud point; thus downhole paraffin treatment not needed
  - Currently treating through slip stream system

- **Slip stream system treatment**
  - Corrosion and scale inhibitor
    - Chemical leaves film for corrosion inhibition
    - High concentration of surfactant to help move solids
    - Quat to help treat for bacteria
  - Flushing chemicals with fluids from tubing through 1/4” stainless steel lines

- **Batch treatments w/ pump trucks**
  - Biocide for bacterial control
  - Weekly, bi-weekly or monthly treatments
    - Depending on results from data
      - SRB and APB counts
      - Fe/Mn counts
      - Chemical residuals from continuous treatment
Hydraulic jet pumps have high risk for chemical issues
- Recycled fluid increases likelihood of high bacteria and scale

Corrosion/Scale inhibitor injection
- Treat power fluid prior to pumping downhole
- Inject at the jet pump suction line (between the power vessel & pump skid)
- Prefer combo products to eliminate the need of multiple pumps and tanks
- Protects against corrosion, scale & bacteria
- Frequent sampling is required
### Artificial Lift Chemical Treatment – Gas Lift

- Methanol treatment in HP lines or across pressure cuts (control valves)

- Downhole corrosion treatment for gas lift wells has not been established yet
  - Concerns due to free-flowing wells that have seen HIT’s from bacteria/pitting

- Options for downhole treatment
  - Corrosion inhibitor via slip stream
    - Chemical treats with corrosion inhibition on external/internal tubing above packer fluid and internal fluid level
    - Helps to protect exposed tubing
  - Batch corrosion film
    - Would require minimum downtime and leave film from EOT up
  - Internal capillary strings
    - High risk wells only
    - Still under evaluation
Surface Chemical Treatment

- **Flowlines**
  - Paraffin treatment where surface temperature is below the cloud point
  - H2S scavenger on some locations with high H2S content

- **Tank Batteries**
  - Paraffin settles in bottom of tanks
  - Paraffin treatment takes care of “tank bottoms” problem

- **Pipelines**
  - Methanol treatment for high pressure (+1,000 psi) wet gas lines

- **Central Processing Facilities (CPFs)**
  - Corrosion and scale treatment – low pressure system

- **Central Gathering Facilities (CGFs)**
  - H2S scavenger

- **Saltwater Disposal Facilities (SWDs)**
  - Scale treatment as water is commingled from different locations
Optimization of Injection Points
Treating Points

**Down Casing**
- Packer Fluid
  - Free flowing and gas lift
- Slipstream
  - Rod Pump
- Capstring
  - None
- Batch
  - Rod Pump

**Down tubing**
- Power Fluid
  - Jet pump
- Capstring
  - None
- Batch
  - Potential biocide and corrosion inhibitor

**Wellsite Facility**
- Wellhead
  - When unable to treat solids issues downhole
- Other Tie-Ins

**Pipeline**
- Continuous
- Batch
- Chemical Pigs

**Central Gathering**
- Continuous
- Batch
- Fit Purpose Treatment

**SWD**
- Continuous
- Batch
- Fit Purpose Treatment

---

What are your issues?

- High fluid levels
- High gas rates up casing
- Downhole solids
- Solids at gathering facilities and SWD’s
- Corrosion and leaks in pipeline systems
Treating Points and Injection Types

- **Batch vs Continuous CI**
  - Batch chosen for higher gas rate wells
  - Oil soluble rather than water
  - Decrease in Fe/Mn when switched
  - Continual treatment for a continual problem

Batch VS Continuous Corrosion Treatment

Switch to continuous

- Fe Well 1
- Fe Well 2
- Fe Well 3
- Mn Well 1
- Mn Well 2
- Mn Well 3
Treating Points and Injection Types

- **Surface vs Downhole CI**
  - Switch of Lift type
  - Data to come
  - Believed benefit of downhole for protection of downhole investment
Treating Points and Injection Types

- Slipstream vs. Capstring
  - Operational cost and issues of capillary tubing
  - We do not have a treating comparison

- Downhole paraffin treatment via capillary string
  - Discontinue paraffin inhibitor based off of cloud points & water production
  - Paraffin inhibitor did not treat root cause of failures

- Downhole scale treatment via capillary string
  - Scale was necessary for ESP’s

- Other areas utilize capstring
Slipstream: Control and Optimization of Injection

- Effort dependent on intervention history and data collected

- Operators give weekly tank levels
  - Includes information of rates, check flush, pumps not working, etc.
  - Informs chemical vendor of status
  - Get operator involved and ownership is taken

- 14 high failure wells currently have tank telemetry
  - Enabled us to find several pumps that were not pumping at night

- Overtreating vs. Undertreating
  - Preference to over treat
  - Telemetry will help us to minimize over treating

- Training focus
  - Chemical trainings on what, why, and economics of treating
  - Pump How To
  - Rates and other refreshers
Raw Data of Corrosion Inhibitor Affect

Iron (total) Fe (mg per l)

Manganese Mn++ (mg per l)
Program Design/Optimization
The Amulet System

**SAP-PM**
- Structure
  - Wells
  - Facilities
  - Equipment

**PDB**
- Production Hierarchy
- Monthly & Daily Prod
- H2S Readings
- Downtime
- Events
- Failures
- Tubular data

**OpenWells**
- Daily Averages
  - Wellhead, Flow-line, Separators, Tanks
  - Pressures, Temperatures, Rates, Levels

**Cygnet**
- Gas Analysis
  - CO2, CH4, H2S ppm, etc

**Flowcal**
- VENDORS

**Amulet DB**
- Structure
  - R&M Work Orders

**Reporting**
- Spotfire and Spotfire Web Player

**Web-based Data Entry Form**

**Chemical Vendor Data**
- Sample analysis results
- Treatment data

**Other Services**
- Hot Oil/Water, Cutting
Treatment and Product Selection: Data Collection

**Oil Analyses**
- Low wax appearance temperature of 75ºF to 120 ºF
- Low wax content of 3-6% with very high water cuts

**Water Analyses**
- Very high Fe and Mn levels
- Some scaling tendencies
- High bacteria levels

**Failure Analysis of Samples**
- Tbg joints with holes and wear
- Rod parts with visible pits
- Solids found during pump breakdown

**Results**
- Potential to discontinue paraffin inhibitor
- Evident corrosive or bacterial wear

![Number of Samples Taken](image)
Fit for Use Chemical Selection

- Free Flowing

- Artificial Lift
  - Chemical package optimized to meet challenges that artificial lift method brings.
  - Gas Lift
  - Jet Pump
    - Combo Product via Power Fluid
  - Rod Pump
    - Corrosion Inhibitor via Slip Stream
    - Combo Products via Slip Stream
    - Batch Biocide
    - Soap Jobs

Generic Examples of Corrosion

- Mechanical wear accelerated by corrosion on pipe interior
- Galvanic corrosion on pipe exterior
- Oxygen-induced corrosion on pipe exterior
Concluding Remarks

- Engineering engagement and collaboration with the chemical technology team for technical data driven decision making
- Investment of time with our vendors and continual evaluation of the design of the chemical program for type of artificial lift method
- Engagement and training of operators for increased knowledge and improved relationships with vendors
- Effective cost cutting while preserving asset value and meeting demands of changing fluid properties and operational changes
Q&A

Contacts:

Amjad Abdelrahman – Field Production Engineer
- Email: Amjad.Abdelrahman@Anadarko.com
- Phone: (432) 248-3872

Amber Helm – Field Production Engineer
- Email: Amber.Helm@Anadarko.com
- Phone: (432) 248-3810