Biological Growth in Frac Water Delivery Systems – A Case Study

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Water Standard and Monarch Separators
Microorganism Diversity in Oil, Gas and Water Systems

- Hydrocarbon-rich environments provide nutrients that expedite growth
- Sulfate-reducing bacteria (SRB), nitrate-reducing bacteria (NRB) and iron-reducing bacteria are problematic

Control Mechanisms

- Physical treatment methods (heat, UV radiation, freezing)
- Chemical methods (biocide dosing, in situ biocide generation, biostatic additives)
- Limit/remove one or more essential elements for growth

Costs of Biological Dosing

- High cost associated with biocide dosing
- $90,000 per well completion not uncommon for associated fracs
Consequences of Biological Activity in Hydrofracturing

- Corrosion of infrastructure
- Well souring and H₂S formation within facility (HSE impacts)
- Reservoir and well damage

Source: Boterro et. al
Biological control at frac sites is challenging

- **Microbes Available**
  - Reuse of frac equipment
  - Incomplete control at water treatment facilities

- **Food Available**
  - Relatively high Total Organic Carbon (TOC) in recycled produced water and some well and surface waters

- **Hospitable Environment Available**
  - Stagnation and idle legs in piped delivery systems
  - Raw water pipeline permitting limitations & inability to dose biocide
Combination of frac and bladder tanks provide storage upstream of blenders.
BAG FILTERS

10,000 bbls

BIOCIDE TANK (DBNPA)

FRESH WATER FROM DELIVERY SYSTEM

WATER STORAGE TANKS (FRAC TANKS)
7,500 bbls

WORKING TANKS (MINION TANKS)
10,000 bbls

WATER TO BLENDER

BIOCIDE TANK (DMO)

Max dose limited to 60 mg/L

Typical frac water storage configuration from project
Frac Biocide Considerations

Adequate tank cleaning

Total biocide demand
  • Types of microbes
  • Algae

Water storage system sediments/biofilms:
eliminate hospitable environments

Select biocides for actual conditions
  • Top side conditions
  • Downhole conditions and residence time
Freshwater System Case Study

200 miles of pipe

Multiple freshwater sources:
  - Groundwater wells and surface sources
  - Fluctuating volumes and water quality

Use of open reservoirs to balance supply & demand

Range of inline filtration within system

Reportable Event considerations – chemical free treatment

Significant hydrofracturing operation in progress
  - Onsite water storage for immediate use

Limited existing water quality data
Additional sampling/field audit to characterize biological environment and water quality through the system.

Identify water management operations that contribute to aging water and eutrophication.

Locate oversized lines, with limited scouring, and dead legs.

Identify practices that contribute TOC into the system (straw for algal control).
Water Delivery is a manned operation, handover of water occurs at the frac site.

From Valve Box at the Pipeline

Source: Bambauer

Source: Gorman Rupp

Source: Bambauer
Water Quality Optimization
## Fresh Water Source Comparison

<table>
<thead>
<tr>
<th>Surface Water</th>
<th>Groundwater</th>
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</thead>
<tbody>
<tr>
<td>Combination of Lake and River Sources</td>
<td>Multiple Well Fields</td>
</tr>
<tr>
<td>Event driven water quality excursions</td>
<td>Higher Salinity (&gt;1500 mg/L)</td>
</tr>
<tr>
<td>• Sediment</td>
<td>• Sulfate (&gt;500 mg/L)</td>
</tr>
<tr>
<td>• TOC (10 mg/L)</td>
<td>• Iron (2-5 mg/L)</td>
</tr>
<tr>
<td>Relatively Low Salinity (&gt;1000 mg/L)</td>
<td>Low turbidity</td>
</tr>
<tr>
<td></td>
<td>Low ATP, Total Bacteria, SRB, APB</td>
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<td>Potential surface water impacts</td>
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</tbody>
</table>
Seasonal Water Source Utilization

Multiple surface sources prone to eutrophication

- Nutrient rich lakes have seasonal algal blooms
- Algae overloads strainers
- Lakes are under water quality management by others, limited intervention possible

River sources prone to event driven water quality changes

- High sediment levels in spring/early summer
- TOC from upstream WWTPs
Pipeline Considerations

Avoiding stagnation is critical

Low velocity is a challenge
- Design for future frac sites can result in very large pipe

Sedimentation in lines is a major challenge
- Location of water demand changes
- Potential for dead legs

Can flushing/pigging be performed?
Sediment accumulation: Typically at low spots with low velocity
Water Age Optimization

Pond operation matters

- Balancing ponds act like standpipe water towers
- Manual pond turnover may be required

Cost optimization sources should consider costs of frac disinfection
Water Age Optimization
# Key Study Findings

<table>
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<tr>
<th>High potential for bacteria from dirty frac tanks and bladder tanks</th>
<th>• Biofilms and sediments in these systems make it difficult to completely disinfect water even at very high biocide doses</th>
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</thead>
</table>
| All water sources, especially produced water, have high TOC and potential for microbial growth | • Oxidants can partially decompose organics making them more assimilable for microbes  
• TOC treatment is expensive |
| Elimination of bacteria in water supply will help reduce the topsides biocide demand | • Filtration and pipeline cleaning to eliminate sediment  
• Water age planning, plus directed line flushing to control bio growth |
Project Next Steps

**Water Management**

- **Minimize**
  - TOC addition into system by utilizing alternative sources at times when TOC loading is high (seasonal and event driven upsets)
  - Address balancing of volumes to reduce biological growth, i.e. dewater ponds periodically or perform regular drawdowns
  - Manage flows to eliminate dead legs and flush low flow lines periodically

- **Evaluate**
  - Cost associated with any improvement versus potential reduction in chemical costs or improvement in frac performance to consider overall decision economics

- **Consider**
  - Additional treatment including finer filtration where it’s value-added based on water quality data
  - Pond water quality controls including air sparging for reservoirs/ponds where practical and warranted

**Project Next Steps**
Conclusions

Biology plays a critical role in cost, HSE and corrosion of hydrofracturing operations and production.

Current best practice involves dosing biocide at multiple points during the frac, which can lead to high OPEX depending on source water quality and biological activity.

As Midstream Water continues to add infrastructure, consideration should be given to managing biological growth to optimize cost overall and not only rely on biocide addition.

Water quality is complex but good design and water management practices can play an important role in reducing biological activity and associated costs.
Questions?

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