## Basic Treatment Requirements

### What Are Your Goals

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Water Treatment Requirements

Microbial Control

Scale Inhibition

Filtration
Non-Oxidizing Biocides
- No compatibility issues?
- Potentially lower cost
- No effect on Iron or Sulfides
- No real time monitoring
- Bacterial resistance concerns
- Efficacy concerns in produced water *

Oxidizing Biocides
- Compatibility issues
- Potentially higher cost
- Oxidizes Iron and Sulfides
- Real time monitoring
- No bacterial resistance concerns
- No efficacy concerns in produced water

* "Produced Water Exposure Alters Bacterial Response to Biocides”, Vikram, A.; Lupus, D.; Bibby, K.; Univ. of Pittsburgh
Microbial Control

Non-Oxidizing Biocides

SPE 14138 “Critical Evaluation of Biocide-Friction Reducer Interactions Used in Slickwater Fracs”
- THPS reduces FR viscosity
- Glut interacts with Oxygen Scavengers, causes crosslinks in certain cases and negative FR interaction in high ORP
- DBNPA, Thione negative FR interaction at higher concentrations

SPE 119569 “Are You Buying Too Much Friction Reducer Because of Your Biocide”
- Quat forms agglomerates in FR
- Quat degrades FR performance
- Quat performance is degraded by FR
Microbial Control

Oxidizing Biocides

Oxidizers:
• Preferential for Microbial Control
• Verifiable treatment, real time methods
• Oxidizes Iron, Sulfides for improved water quality
• Increases ORP, reduces breaker dose, improves breaker performance
• Must control compatibility !!!!!

Ozone

Chlorine Dioxide

Sodium Hypochlorite

Hydrogen Peroxide
# Disinfection vs. Compatibility

<table>
<thead>
<tr>
<th>Oxidant</th>
<th>Oxidation Potential, V</th>
<th>Half-Life @ 20°C</th>
</tr>
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<tbody>
<tr>
<td>Hydroxyl Radicals</td>
<td>2.8</td>
<td>&lt; 1 sec</td>
</tr>
<tr>
<td>Ozone</td>
<td>2.3</td>
<td>20 min.</td>
</tr>
<tr>
<td>Hydrogen Peroxide</td>
<td>1.8</td>
<td>Hours</td>
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<tr>
<td>Chlorine Dioxide</td>
<td>1.5</td>
<td>93 min.</td>
</tr>
<tr>
<td>Chlorine</td>
<td>1.4</td>
<td>140 min.</td>
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Disinfection vs. Compatibility

*Friction Testing Device*

- Tap water supply
- Pressure reducing valve
- Shut off valve
- Flow control valve
- 50+ cm section of 3/8” tubing
- Test section
- 7 or 200 kPa pressure sensor
- 7 kPa pressure sensor
- Volumetric Detector
Water Treatment Requirements

Microbial Control

Scale Inhibition

Oxidizers !!!!!

Filtration
Water Treatment Requirements

Microbial Control

Oxidizers !!!!!

Scale Inhibition

Filtration
Bag Filtration

What are the Basics?

- Bag Filtration
- Bag Fit
- Filter Pod Quality
- TSS Goals
- TSS Size Distribution
- Micron Size
- TSS loading
Water Treatment Requirements

- Microbial Control
- Oxidizers
- Scale Inhibition
- Blending
- Scale Inhibitors
- TDS Removal

Filtration
Water Treatment Requirements

Conventional Treatment Program

Blend

Disinfection

Pre-treatment TDS Removal
- Floc and drop
- EC
- Resins

Fresh/Brackish Water

Produced Water
Water Treatment Requirements

Conventional Treatment Program

Blend for Scale Inhibition

Disinfection

Pre-treatment

Fresh/Brackish Water

Produced Water
Water Treatment Requirements

Conventional Treatment Program

Blend for Scale Inhibition

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Produced Water
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Water Treatment Requirements

Conventional Treatment Program

Blend for Gel Compatibility

Disinfection

Fresh/Brackish Water

Produced Water

Pre-treatment

Produced Water

X
Cross-linked gel fluids

- Gel Compatibility can be maintained over narrow range.
- TSS, TDS, Chlorides and Boron are all issues.
- Once Gel recipe is developed water quality must remain in a narrow range to maintain gel compatibility.
- Control of water quality is paramount.
Gel Compatibility Testing

Rheology Testing
- Viscosity
- Gel Stability
- Break Time
Recycling for Crosslink Gel Fracs
Quality Assurance / Quality Control Program

Fresh Water Pit

Produced Water Storage

QA/QC

HYDROZONIX
Recycling for Crosslink Gel Fracs
Quality Assurance Quality Control Program

• Mix/Recirculate Produced Water Source
• Calibrate Pumps for Consistent Blend
• Real Time Monitoring of TDS
• Real Time Monitoring of Chlorides
• Real Time Monitoring of Boron
• Real Time Monitoring of Other Parameters
Temperature Stratification

- Even a 0.1 °C (0.18 °F) or greater temperature difference can inhibit mixing
- Without mixing thermal stratification occurs
- Without mixing only slight diffusion takes place as the only mechanism to transfer biocide
- Water age becomes an issue, newer colder water sinks to bottom, warmer water stays in tank longer
- Bacterial growth is supported

Cold water will not rise into the lighter, warmer water
Produced Water Mixing

Stratification

• A static, unmixed pit will stratify
• Chlorides will increase with depth
• Temperature will decrease with depth
• Zones are created at different depths with changing water quality
Water Treatment Requirements
Produced Water Requiring Accumulation

Conventional Treatment Program

Blend

Disinfection

Fresh/Brackish Water

Produced Water w/ Aeration
Water Treatment Requirements

Produced Water with Accumulation Time

- Aeration
  - Bacterial Control
  - Iron Oxidation
  - Sulfide Oxidation
  - $0.01-$0.02/bbl

- Oxidation
  - Bacterial Control via Oxidation
  - Iron Oxidation
  - Sulfide Oxidation
  - $0.20-$0.22/bbl

- Filtration
  - Solids Control
  - $0.01-$0.02/bbl
Water Treatment Requirements

Aeration
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## Aeration:

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<tr>
<th>Aerator Type</th>
<th>Lbs O$_2$ / HP</th>
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<tbody>
<tr>
<td><strong>Surface Aerator:</strong> Odor Control, odor cap</td>
<td>1-2 (top 2 feet)</td>
</tr>
<tr>
<td><strong>Aire-O2:</strong> High Energy, poor O$_2$ transfer</td>
<td>2</td>
</tr>
<tr>
<td><strong>Submersible:</strong> Most Energy Efficient for Mixing, Good O2 transfer, flexible for surface, depth or mixing and aeration</td>
<td>4</td>
</tr>
<tr>
<td><strong>Bubble Diffusing Line – Submersible:</strong> Lowest capital cost, but high capital for compressors, Poor mixing, good O2 transfer, requires high pressure, more energy</td>
<td>5-10</td>
</tr>
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**Aeration: Surface vs Submersible**

**Surface Aeration**
- Reduces total hp required
- Provides odor control
- Some improvement in water quality for shallow water (< 6 feet)
- Poor mixing, except in shallow water (< 6 feet)
- Provides some icing inhibition

**Submersible Aeration**
- More hp required
- Provides odor control
- Improves water quality
- Provides good mixing
- Agitates accumulated solids for easy removal
- Provides icing inhibition
Water Treatment Requirements

- Aeration
  - Bacterial Control
  - Iron Oxidation
  - Sulfide Oxidation
  - $0.01-$0.02/bbl

- Filtration
  - Solids Control
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- Oxidation
  - Bacterial Control via Oxidation
  - Iron Oxidation
  - Sulfide Oxidation
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Testing Program

- Unique Hydrozonix Feature
- Real Time Water Quality Testing
- Creates certainty for treatment verification
- Includes testing Hydrocarbons, Iron, TSS and Bacteria
- Test all key parameters once per shift, more frequently when water quality changes
- Inline probes for ORP and pH
- Hydrozonix has developed proprietary sample prep procedures

InfraCal 2 ATR-SP
EPA Method 1664

HACH DR 900 for TSS and iron

ATP Kit for Real Time Bacteria
Bacteria Testing
Where do I Sample?

- Influent/Effluent of Treatment System
  - MPN
  - ATP
  - Continuous Testing
- Residual Disinfection / Working Tanks
  - ATP
  - Continuous Testing
- Source Water
  - ATP
  - MPN
  - Baseline Testing
Summary

• **Recycling/Reuse Can be Low Cost** – Less than $0.26/bbl for a complete program of aeration, filtration, oxidation and real time monitoring.

• **Oxidizers are Best** – Effective over wide range of water quality, including 100% produced water as a biocide replacement. Also provides Iron and Hydrogen Sulfide control. Real time testing helps optimize

• **Aeration** – Low Cost Pre-Treatment when needed or for longer storage requirements. Overall improved water quality. Submersible aerators work best and provide the most benefit.

• **Filtration** – An often overlooked, but critical component to a recycle/reuse program. Do a field grain size test and pick the best micron bag.

• **Compatibility** – While other techniques can cause incompatibility we actually improve it by choosing the right oxidizer and using real time monitoring.

• **Real Time Testing** – Most water treatment approaches provide no real time testing, they rely on a “hope for the best” approach. Real time testing is critical for a successful produced water recycling/reuse program. Testing should include working tank monitoring and Flowback testing.
Questions ?

www.hydrozonix.com