EPA HF Study Technical Workshop: Chemical and Analytical Methods

Crosslinked and Linear Gel Composition

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# Fracturing Fluid Composition

## Fluid Types
- **Water-based Fluids**
  - Linear Polymer Solution
  - Crosslinked Gel
  - Viscoelastic Surfactants
- **Oil-based Fluids**
- **Acid-based Fluids**
- **Multiphase Fluids**
  - Emulsions
  - Foams
  - Energized

## Additives
- Gelling Agents
- Crosslinkers
- Breakers
- Fluid Loss Additives
- Biocides
- Thermal Stabilizers
- Surfactants
- Clay Control Additives
Gelling Agents

• **Increase Fluid Viscosity for Improved Proppant Transport**
  - Into perforations
  - Along fracture

• **Reduce Fluid Loss to Reservoir**
  - Deposit filtercake
  - Viscous resistance in porous media

• **Create/Maintain Desired Fracture Geometry**

• **Reduce Friction Pressure Loss in Wellbore**
  - Slick Water applications
Common Frac Fluid Gelling Agents

- Guar
- Guar Derivatives
  - Hydroxypropyl Guar (HPG)
  - Carboxymethyl Guar (CMG)
  - Carboxymethyl Hydroxypropyl Guar (CMHPG)
- Cellulose
  - Hydroxyethyl Cellulose (HEC)
  - Carboxymethyl Hydroxyethyl Cellulose (CMHEC)
- Synthetic Polymers
  - Polyacrylic Acid (PAc)
  - Polyacrylamide (PAm)
  - Partially Hydrolyzed Polyacrylamide (PHPA)
  - Acrylamido-methyl-propane sulfonate (AMPS)
- Viscoelastic Surfactants
  - Cationic
  - Anionic
  - Amphoteric
### Typical Usage Rate of Frac Fluid Gelling Agents

<table>
<thead>
<tr>
<th>Polymer</th>
<th>Concentration (by weight)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Guar</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>HPG</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>CMHPG</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>HEC</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>CMHEC</td>
<td>&lt; 1%</td>
</tr>
<tr>
<td>Synthetic Polymers</td>
<td>&lt; 0.05%</td>
</tr>
<tr>
<td>Viscoelastic Surfactants</td>
<td>&lt; 2%</td>
</tr>
</tbody>
</table>
Crosslinkers

- Increase Effective Molecular Weight by Chemically Linking Polymer Chains
- Create 3D Structure - Increases Elasticity and Suspension Properties
- React w/ Specific Sites (Functional Units) on Polymers
- Each Crosslinker Has Unique Reaction Requirements and Behavior
Common Crosslinker Compounds

Metallic (Ti & Zr)
- Chelated Compounds
  - Retard Oxide Formation
- Crosslinking Rate Controlled by Complex Stability and Ligand Concentration
- Non-reversible
- Shear Degraded

Borate
- Simple Salt ($H_3BO_3$ & Borax)
- Slowly Soluble Salts (Ca and Mg Salts)
- Borate Esters
- Polyborates
## Typical Usage Rate of Common Crosslinker Compounds

<table>
<thead>
<tr>
<th>General Class</th>
<th>Concentration Range</th>
</tr>
</thead>
<tbody>
<tr>
<td>Borate</td>
<td>&lt; 150 ppm as Boron</td>
</tr>
<tr>
<td>Titanate</td>
<td>&lt; 150 ppm as Titanium</td>
</tr>
<tr>
<td>Zirconate</td>
<td>&lt; 100 ppm as Zirconium</td>
</tr>
</tbody>
</table>
Breakers

- **Purpose**
  - Improve Flowback & Maximize Conductivity

- **Mechanism**
  - Reduce Polymer Molecular Weight
  - React with Specific Sites in Polymer Chain
  - Reverse Crosslinking (Borate Only)

- **Common Types**
  - Oxidizers
    - Persulfate
    - Perborate
    - Hypochlorite
    - Mg & Ca Peroxide
  - Enzymes
  - Acids
    - Esters of hydroxycarboxylic acids
References


Questions?