

*EPA HF Study Technical Workshop:
Chemical and Analytical Methods*

*Crosslinked and Linear Gel
Composition*

Richard Hodge

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

<i>Polymer</i>	<i>Concentration (by weight)</i>
<i>Guar</i>	<i>< 1%</i>
<i>HPG</i>	<i>< 1%</i>
<i>CMHPG</i>	<i>< 1%</i>
<i>HEC</i>	<i>< 1%</i>
<i>CMHEC</i>	<i>< 1%</i>
<i>Synthetic Polymers</i>	<i>< 0.05%</i>
<i>Viscoelastic Surfactants</i>	<i>< 2%</i>

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

General Class	Concentration Range
<i>Borate</i>	<i>< 150 ppm as Boron</i>
<i>Titanate</i>	<i>< 150 ppm as Titanium</i>
<i>Zirconate</i>	<i>< 100 ppm as Zirconium</i>

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

1. "Chapter 7: Fracturing Fluids and Additives", *Recent Advances in Hydraulic Fracturing - SPE Monograph Series Volume 12* ; Society of Petroleum Engineers, 2001.
2. "Chapter 7: Fracturing Fluid Chemistry and Proppants", *Reservoir Stimulation – 3rd Edition*; John Wiley and Sons, 2000.
3. "Chapter 7: Fracturing Fluids and Formation Damage", *Modern Fracturing* ; Energy Tribune Publishing Inc., 2007.



Questions ?