Oil Production
Facilities and Chemicals

SA Lordo
Topics

- Hydraulic Fracking
- Production
What is Fracking?

- Injection of fluid into a horizontal drilled well (depth 5,000-20,000 ft)
- The fluid injected into the rock is typically a slurry of water, proppants, and chemical additives.
  - Fractures are formed using charges or hydraulically
- The fluid used contains 95+% water, sand (proppants), and chemicals
- Chemicals used are tailored for the geology of the formation
- After fracking, the fluid is removed (flowback)
What Chemicals are Used?

- **Base Fluid is a cellulose or a Guar derivative**

- **Conventional linear gels**
  - Guar based fluids are cross-linked with Boron ions (from aqueous borax/boric acid solution).
    - Raises viscosity to allow transportation of the proppants (sand). These gels have higher viscosity at pH 9 onwards and are used to carry proppants.
    - After fracking, the pH is reduced to 3 - 4 so that the cross-links are broken and the gel is less viscous and is therefore pumped out.

- **Organometallic- cross-linked gels**
  - Zirconium, Chromium, Antimony, Titanium Salts can be used to cross-link guar based gels.
    - The cross-linking mechanism is not reversible. So once the proppant is pumped down along with the cross-linked gel and the fracturing part is done. The gels are broken down with appropriate breakers.

- **Aluminum phosphate-ester oil gels**
  - Aluminium phosphate and ester oils are cross-linked to form a gel
    - These are one of first known gelling systems. They are very limited in use currently, because of formation damage and the difficulty in clean-up.
Matrix Stimulation - Acidizing

- Acidizing has been extensively used since to improve oil and gas production
- Identification of formation damage key to stimulation success
- Chemistry of the stimulation fluids
  - Dissolve or disperse impairment damage
  - Dependent upon type of formation
- Hydrochloric acid systems – primarily carbonate formations and preflush for Mud Acid Treatments
- Organic acid systems – also for carbonate formations and preflush for Mud Acid Treatments
- Special acid systems - HCl systems for specific requirements
- Chelant Systems
# Fracking Additives

<table>
<thead>
<tr>
<th>Applications</th>
<th>Chemistries</th>
<th>Impact Crude Unit Process</th>
</tr>
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<tbody>
<tr>
<td>Surfactants</td>
<td>Acids (citric, latic, etc.); Isopropanol</td>
<td>Potentially</td>
</tr>
<tr>
<td>Cross Linkers</td>
<td>Boric acid(s), Al, Zr, KCl, NH4Cl, CaCl2</td>
<td>yes</td>
</tr>
<tr>
<td>Breaker</td>
<td>Ammonium Persulfate</td>
<td>Potentially</td>
</tr>
<tr>
<td>Scale Control</td>
<td>Phosphate esters, Phosphonates, glycols</td>
<td>Potentially (Fouling)</td>
</tr>
<tr>
<td>Biocides</td>
<td>Gluteraldehyde, etc.</td>
<td>Potentially (WWT)</td>
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<tr>
<td>Gels</td>
<td>Guar Gum, hydroxyethyl cellulose, phosphate esters</td>
<td>Phosphate ester (yes); others no impact</td>
</tr>
<tr>
<td>Corrosion Control</td>
<td>Formic Acid, KI, Sb, Imidazolines, Quat Amines, Amides</td>
<td>Potentially</td>
</tr>
<tr>
<td>Pipe Cleaner</td>
<td>HCl, HF, HBr, DDBSA</td>
<td>Yes</td>
</tr>
<tr>
<td>Paraffin Control</td>
<td>Polyalphaolefin polymers</td>
<td>Some (chlorinated versions)</td>
</tr>
<tr>
<td>H₂S Scavenger</td>
<td>Trazines</td>
<td>Yes (depends on type)</td>
</tr>
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</table>
Primary Production Facility

- Separate oil / condensate, water & gas.

- Pump condensate to storage / treatment / sales
  - To pipelines / tanks / processing tankers (FPSO)

- Compress gas
  - Gas lift, fuel, reinjection or sales

- Clean up water for disposal or injection
  - Disposal must meet environmental standards
Typical Deepwater Field
Typical Land Field Production
System Goals

- BS & W < 1% (US); <0.5% overseas
- Oversea salt specs 10-50 Pounds salt per 1000 BBLS Crude
- Oil & Grease < 29 PPM, no visible sheen
- Acceptable water quality for injection on land based production
- 10ppm OIW for surface disposal
- Dew Point < 3-7 lbs./MMCF
- Asset Integrity (no leaks)
- Flow Assurance (100% of the time)
Flow Assurance

- Definition: to provide assurance of production throughout a designated flow line
- Major chemical issues include:
  - Hydrates
  - Asphaltenes
  - Corrosion
  - Paraffin
  - Antifoams
Oil / Water Separation - Demulsification

Many Types of Available Chemistries:

- Polyol Esters
- Cross Linked Polyols
- Cross Linked Resin/Polyols
- Polyamine Oxyalkylates
- Sulfonates
- Oxyalkylated Phenols
- Resins (low oxide)
- Resins (high oxide)
Wax Control

- Solvents
- Dispersants
- Surfactants (cationic, anionic, nonionic)
- Inhibitors
  - Crystal modifiers
  - Pour-point depressants
Corrosion Inhibitors

- Dissolved gases are major contributor to oilfield corrosion

- 3 Gases of concern: $O_2$, $CO_2$, $H_2S$

- Contamination naturally present

- If no soluble gases; pH of brine $\sim 7.0$
  - Corrosion greatly reduced
Chemistry of CIs

- Primary monoamines
- Polysubstituted monoamines
- Diamines
- Polyamines
- Imidazolines
- Quaternary ammonium compounds
- Phosphate Esters
Natural Gas Hydrates

- Ice-like crystals form when water and natural gas cool under pressure.

- Hydrate formation occurs when water and natural gas mixtures above 500 psi cool below 60-75°F.

- There are about 8 guest molecules per 46 water molecules.
Hydrate Control

Absorption
- Glycol dehydration
- Calcium chloride

Condensation
- Chilling
- Joule-Thomson cooling

Adsorption
- Alumina or silica
- Molecular sieves

Others
- Membranes
- Gas stripping
- HC displacement

Chemical
- Methanol
- Glycol
- LDHI (newest)
TYPES OF SCALE INHIBITORS

- Phosphonates
- Phosphate Esters
- Polyacrylates
- Specialty Polymers
- Inorganic Phosphates
- Chelants
- Combinations
Biocides

The Real Oilfield Troublemakers

- Microbial Influenced Corrosion (MIC)
  - SRB / APB

Bacteria in the Oilfield

- Aerobic
  - Require oxygen for metabolism and growth
- Anaerobic
  - Do not require oxygen for metabolism and growth (O2 is toxic)
- Facultative
  - Biological “switch hitters”
    - Do fine with or without oxygen
Types of Biocides

- Chlorine, Bromine
- Chlorine dioxide
- Glutaraldehyde
- THPS
- Amines/diamines
- Quaternary amine compounds
- Isothiazolines
- Imidazolines
- Acrolein
- Bronopol
- DBNPA

Oxidizing

Non-oxidizing
### Production Additives

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<td>Trazines</td>
<td>Yes (depends on type)</td>
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<tr>
<td>Corrosion Control, Biocide</td>
<td>Quantanary Amine Chloride salts</td>
<td>Potentially</td>
</tr>
<tr>
<td>Emulsion Breaking</td>
<td>Water treating polymers</td>
<td>Low probability (water-based)</td>
</tr>
<tr>
<td>Emulsion Breaking</td>
<td>Metal salts (ZnCl$_2$, AlCl$_2$, poly(aluminum) chloride)</td>
<td>Yes - corrosion</td>
</tr>
<tr>
<td>Emulsion Breaking</td>
<td>Oxyalkylate resins</td>
<td>No</td>
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**Risk Levels:**
- **High Risk**
- **Pot. Risk**
- **Low Risk**
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<td>Paraffin control (Dispersants &amp; Inhibitors)</td>
<td>Solvents, Polyalphaolefin polymers</td>
<td>Some (chlorinated solvents)</td>
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<tr>
<td>Scale Control, Corrosion Control</td>
<td>Phosphate esters, Phosphonates</td>
<td>Yes - corrosion, fouling</td>
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<tr>
<td>Scale Control</td>
<td>Acrylic acids</td>
<td>Yes - corrosion</td>
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<td>Biocides</td>
<td>Gluteraldehyde and others</td>
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Upstream Key Takeaways

- Each formation is unique
- High initial production and steep decline means continuous drilling and completions
- Extremely variable crude quality due to geology and production methods
- Completion and production chemicals are mostly water soluble
Issues in Shale and Tight Oil Plays

- $\text{H}_2\text{S}$
- Heavy Molecular Weight Paraffin
- Scaling
- Microbes
- Corrosion
- Some emulsions

Top Production
Chemicals used in most EagleFord fields
Refinery Solutions

- Monitoring/Trending
- Desalter optimized programs
- Crude stability testing
- Proper neutralizer and corrosion inhibitor selection, monitoring and control
- Advanced salt dispersants to control crude column or pump around fouling
- Bacteria monitoring and biocide treatment program in tank farm
Summary

- While there are many chemistries that are used in oil production operation few will impact typical refinery operations

- Major impacts from post-production additives (ie, H₂S) and well stimulation/acidification additives (ie, HCl, Amines, etc.)