Water recycling in the oil field – how one service company does it

Clay Maugans, Ph. D. - Select Energy Services
Outline

- Different frac’s use different chemistry
- Water quality needs – Chem 101
- Treatment techniques
  - Low-level
  - Mid-level
  - High-level
- Bonus challenges
Different formations need different frac strategy

- **Geology**
  - Shale/tight sandstone/porosity
  - Permeability
  - Minerals
  - Frac program:
    - Linear
    - Bilinear
    - Radial
- **Vertical Well**
  - More often use simpler chemistry
- **Horizontal Well**
  - More often use complex chemistry fracs
What are the different types of frac packages?

- **Slick**
  - Forgiving chemistry (FR)
  - Consumes more water/stage
  - Minimal treatment

- **Gel**
  - Variable complex chemistry
  - Variable treatment needs
  - More water efficient/stage

- **Crosslink Gel**
  - Complex chemistry
  - Highest water quality needs
What happens if I can’t use fresh water and have contaminants? Frac contaminant chemistry 101

- Biological activity
- Turbidity (TSS + oil)
- Iron (Fe)
- Hardness & Sulfate
- Salts (including Boron)
Frac contaminant chemistry 101

- Biological activity
  - Slime formation (loss of conductivity)
  - $\text{H}_2\text{S}$ formation (safety and quality loss)
  - Corrosion (acid byproduct corrosion of piping and equipment)
Frac contaminant chemistry 101

• Biological activity
  • Slime formation
  • \( \text{H}_2\text{S} \) formation
  • Corrosion

• Turbidity (TSS + oil)
  • Consumes friction reducer (chemical bill goes up)
  • Solids can plug gaps between proppant (loss of conductivity)
  • Oil content is bug food during storage (water & well fouling)
Frac contaminant chemistry 101

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- Iron (Fe)
  - Can react and precipitates as a scale down hole (loss of conductivity)
  - Frac chemistry interference (particularly crosslinkers)
Frac contaminant chemistry 101

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  - Frac chemistry interference
- Hardness & Sulfate
  - Scaling (loss of conductivity)
  - Interference with frac chemistry (crosslinkers + hydration of FR)
Contaminants: What do they do?

Frac contaminant chemistry 101

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  - H₂S formation
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- Iron (Fe)
  - Can react and precipitates as a scale down hole
  - Frac chemistry interference
- Hardness & Sulfate
  - Scaling
  - Interference with frac chemistry
- Salts
  - Affects frac chemistry (hydration & crosslinking)
  - Affects clay swelling (a good thing)
Recycle treatment levels

• Low level: Basic
  • Forgiving system and more is not needed
  • Willing to accept some risk

• Mid level: Clean brine
  • Target contaminant removal
  • Some risk mitigation

• High level: Fresh water
  • All TDS removed
  • Risk elimination
  • Simplified water logistics
Low level: Used for diluted and forgiving frac

- Bag filter
  - Pump through a pod with 50-100 micron sack filters
  - High rate and removes gravel, turtles, and twigs
  - Essentially no effect on anything else
- Bag filter + biocide
  - Same as above, plus sterilizes the water
- Field oxidation (ClO₂, H₂O₂, etc.)
  - Good sterilization
  - Harsh chemicals - require some care to avoid sending residual oxidizer downstream
  - Can create a solids byproduct issue

40Kbbi tank 50% full of sludge
Mid level: Clean Brine - Good enough for most frac’s with low risk

- EC + chemical treatment
  - Electrical current to aid coagulation
  - Chemical addition for further treatment
  - Settling tanks and polish filtration
  - Removes turbidity, Fe, bugs, and some hardness
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- Mobile clarification
  - Chemical addition for solubility adjustment and flocculation
  - Settling chambers with inclined plates for turbidity removal
  - Removes turbidity, Fe, bugs, some hardness
  - Filter press to minimize solids – dry cake solid waste
Mid level: Clean Brine – what if I want high rate treatment?

- Oxidation + solids management
  - ClO₂ oxidation, which is traditionally done for bio-kill.
  - Also a good mid-level recycle treatment – WHEN APPLIED CORRECTLY. Removes turbidity, iron, and sterilizes.
  - Integrated.
- High rate treatment (40k bbl/day flowback. Same rate as frac with fresh water).
- Differentiating ClO₂ approach
  - Professional. $55MM development program.
  - 20 units.
  - Over 1000 inputs into the PLC for control.
  - Top safety integration.
  - Control every drop of water, not just a slip stream like most providers.
Water purification – High level: Good for all frac

- Oxidation plus membrane (OMNI)
  - Pretreat with: Ozone + chem-treat before membrane
    - Removes Fe, turbidity, bio, and some hardness
    - Oxidizes or removes membrane harming organics
  - Followed by membrane treatment
    - First banks of membrane removes all the hardness
    - Final bank of membranes remove TDS – giving pure water
    - Low TDS water: removed nearly all contaminants
Water purification – High level: Good for all frac – risk elimination

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- Thermal evaporation (NOMAD)
  - Pretreat with mobile clarification
    - Remove Fe, turbidity, bio, and some hardness
    - Dry cake solid waste
  - Distill with mechanical vapor recompression
    - High thermal efficiency (20x higher than simple boiling)
    - Distillate quality water - some states allow to transfer/store/handle like fresh water
Points to remember

• Economics rarely sell recycling – it’s lack of availability that sells it
• There is no one-solution, because different frac calls for different quality water, that has different starting points.
• Select does not develop or own a water treatment technology – we partner with the developers and work with their operations to execute an overall project that includes the right treatment tech.
Purpose: Insufficient fresh water, so recycle high H$_2$S produced water for frac

Who: Apache

Job: Mob/Demob to central site and produce 250,000 BBL for use in a 4 well frac program

When: May - July 2013

Where: Notrees TX, Permian Region

What: Fountain Quail ROVER system + H$_2$S agent; Big Holdings containment; transfer

How: Neutralize H$_2$S; remove turbidity & Fe; kill bacteria; make clean high TDS reuse water for frac; inventory in tank; minimized solids waste

Result: Wells frac’d on schedule and on budget. Just starting another 40 well treatment campaign with same customer using the ROVER.
Additional oilfield water challenges to manage

• Sulfide laden water management
  • Oxidize (ClO₂, H₂O₂, Ozone)
  • Sequester (Agent)
• Stagnant water pit souring
  • Manage by aeration to oxygenate and prevent SRB from souring
• Pit volume uncertainties
  • 1-time Remote boat surveys with soundings for pit depth mapping
  • Real-time depth monitoring sensor with satellite coms.
• Zero liquid discharge
  • Complete elimination of all liquid streams – it’s an option.
• Overall water program management
  • Service providers:
    Source, transfer, containment, monitoring, treatment, disposal.