Production Chemistry Management in Geothermal Assets: Key Learnings & Differences from Oil & Gas Production
Overview

Production Chemistry Challenges Common to Oil & Gas and Geothermal

The main differences in these challenges

Where shared learnings have resulted in success
Production Chemistry Challenges

**Integrity**
Corrosion by CO₂ gas produced with formation water results in corrosion of metal

**Flow Assurance**
Pressure and temperature change can lead to insolubility of mineral scales resulting in deposition

**Injectivity**
Solids such as mineral scale, corrosion products and bacterial biofilms can cause problems in injection wells

These challenges are well known and managed in Oil & Gas Industry
Integrity Management

To achieve lifetime design; corrosion rates must be reduced

Similarities to Oil & Gas Industry:

- Metallurgy selection: Corrosion Resistant Alloys can be used or GRE linings
- Injection of corrosion inhibitor chemicals can significantly reduce corrosion rates
- Corrosion rates are monitored by inline coupons and probes and water chemistry monitoring

Key Differences

- Flow rates significantly higher >400 m³/hr.
- Minimal hydrocarbon phase.
- Geothermal wells cemented casing vs oilfield well tubing - operationally difficult to intervene/replace.
- Casing sizes and lead times can exclude CRAs.
Oilfield Corrosion Inhibitors

- Minimal hydrocarbon phase results in gunking/build up of greasy deposits
- Impacts on injection well pressure
- Remedial treatments can be required to reduce well pressures
- More water-soluble corrosion Inhibitors have been shown to avoid these problems
Radioactive Deposits

- Radioactive $^{210}\text{Pb}$ deposits widely reported in Slochteren and Delft reservoirs in Netherlands and other regions in Europe.
- Pb can cause corrosion and leaves radioactive deposits over metallic structures.
- HSE implications for removal and handling.
- Expensive for specialist removal.

Oil & Gas experience
- Seawater Injection in Oil and Gas – H$_2$S causes PbS precipitation held in reservoir as mineral.
- Potential in Dutch gas production but not widely reported.

\[ \text{Fe}^0 - 2e \rightarrow \text{Fe}^{2+} \]
\[ \text{Pb}^{2+} + 2e \rightarrow \text{Pb}^0 \]
Mitigation for Lead Deposition

- Use of corrosion inhibitors have been shown to reduce quantities of lead deposits
- GRE linings can prevent Pb contact with iron downhole, but may displace the problem to surface
- Lead deposits can be dissolved by nitric acid
- Very little technology available to prevent/mitigate elemental lead formation which will be key to achieving optimal production rates
Scale

Similarities to Oil & Gas Industry
• Pressure and temperature changes from Reservoir to surface cause mineral precipitation
• Silica Scales in HPHT/ASP flood applications

Key differences to Oil & Gas production
• Only formation water is re-injected, no incompatible brine mixing
• Self-Scaling mechanisms dominant
• Temperature decreases rapid cooling effects
• Operational impacts require careful management
• Heat exchanger scaling effects can be observed in real-time
• Lithium extraction systems are sensitive to solids will require scale control
Injectivity

• For reservoir pressure maintenance all produced brine is reinjected

• Unlike offshore Oil & Gas production, no option to reroute fluids

• Capacity to inject at safe injection well pressures is critical to achieve high flow rates

• Bacterial growth / biofilm formation can cause injection well pressure increases

• Periodic biocide treatments can prevent and alleviate pressure increases
Conclusions

• Oil & Gas Industry learnings/best practice valuable
  – Significant production chemistry problems exist
    • Corrosion, scale, microbiology challenges are similar to predict
  – Management strategies required from the Basis of Design
    • Prevention is better than cure
    • Chemical or engineering

• Key differences in Geothermal production require changes to the production chemistry management approach
  – Lack of hydrocarbons
    • Different chemistries
  – Criticality of solids on Injection well pressures, heat exchangers and lithium extraction processes