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Scale Management: Learning from the past and present to reduce costs in the future

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Permian Scale Management Opportunities

- Where we are the current challenges ?
- What can we learn from experience elsewhere ?
- How can we capitalise on past learnings and apply them optimally to the Permian ?
- How does the future direction of water management align with scale management ?
- How can we leverage local infrastructure and global expertise to maximise value delivery ?

Is there value in managing scale?

- Proactive water management is key to all aspects of well completions and operations
- Solids deposition management is key to water management
- Integrated proactive scale management is key to solids management
- In the Permian people are looking to build the first billion dollar water management company

What else is impacted by scale management (or mismanagement) ?

- Water trading
- Water re-use
- Operations Opex: Well scale risks, water chemistry, field conditions and inhibitor needs
- Material Selection & HSSE: Microbial activity and souring prevention
- Fluid Management: Treatment compatibility with corrosion, paraffin, and asphaltene inhibitors and de-foaming, emulsion breaker, biocide, EOR, polymers, and water clarifier additives.
- Water collection pipelines and commingling of different waters
- Local water processing and clean-up
- Road impact due to re-treat frequency
- Subterranean water trespass
- Air quality due to trucking and disposal ponds
- Water Management Choice: Cost of water trucking, transport and pumping v local water purification
- Water clean up by-products disposal e.g. salt

Business Challenge Driven Global Scale Management Efforts

- US foundations (1970's and earlier?)
- Global challenge for Alaska, N. Sea, GoM DW, Brazil, Columbia, Angola, Middle East and Permian
- Advances in deployments, lifetimes, chemistries and detection methods deliver value
- Applying global and local learnings are key to pushing the envelope and managing water challenges
- Needs for large high rate wells are similar to smaller wells but economics differ

Unique Permian Challenges

GoM	Typical Max Summer Temperature	Typical Min Winter Temperature	Typical Well Rates at Plateau (bbl/d)	Comparative Cost of Wells	Typical No. of Wells per Development
Alaska	50 F	-25 F (-40 F 2007)	1000s-10000s	***	10s
North Sea	77 F (Platform)	39 F (Subsea) Storage lower	1000s-10000s	****	10s
Middle East	120 F	75 F	1000-1000s	**	1000s
Permian	**100 F**	**30 F**	**100s**	****	**100s**
GoM	100 F	39 F	10000s	*****	10s

Lessons from Alaska

- Onshore high value wells with barium sulfate and calcium carbonate challenges
- Limited benefit from acidization as acid can’t dissolve barium sulphate
- Frack packs needed to bypass reservoir damage to restore and sustain high production
- Limited number of wells and have to access reservoir beyond formation damage zone
- Scale inhibitor in frac fluids gives “pre production squeeze” that lasts the life of the well and compliments fracking approach
- Field results and scale-free well value delivery confirm frack pack scale inhibition approach assures scale free production at minimal incremental cost

Lessons from the North Sea

- Offshore high value wells in 10s-100s m of water with barium sulphate and calcium carbonate challenges
- Wells mainly cased and perforated
- Bullhead scale squeeze deployment with water chemistry and SI residual monitoring has become routine, development of local sample analysis critical
- Cost of squeeze treatment in terms of well downtime and pumping costs far exceed cost of chemicals
- Long squeeze lives desired by operators and extended squeeze life scale inhibitors have been developed and deployed but limited uptake
- Multizone wells were developed but challenges associated with the need for diversion and initial focus on bullheaded wax diversion for chemical placement had mixed results
- Good success with diversion on high rate subsea wells
- Scale inhibitor squeezes though ESP's pioneered to protect wells and ESP's from scale and learnings later adopted and applied in Alaska.
- Large Scale Sulphate removal for barium sulphate scale management pioneered offshore on Marathons Brae field

Global Learnings

Brazil

- Polymaleate technology pioneered in Brazil later used with good success in N Sea and GoM

Angola

- Sulphate Removal adopted and Marathon Brae learnings taken to next level on most fields
- Frack pack scale inhibitor deployment technique from Alaska used successfully on at least one field
- Good sampling and monitoring indicated no need for carbonate squeeze in near well bore for Angolan wells protected by SRP water injection
- Time to get samples out of country limits complex analysis inputs

GoM

- Frack Pack scale inhibitor planned based on Alaska learnings
- Use of EGMBE to minimize formation damage and enhance squeeze life and facilitate well clean up pioneered and applied at scale
- SI impregnated proppant “insurance” for initial water production deployed
- Time to get samples to beach and analyzed still lags N Sea

Scale Inhibitor Qualification Considerations

- Essential to consider chemicals: chemical – chemical impacts e.g. impact on performance of mixing with fracking additives, corrosion inhibitors, de-foamers, emulsion breakers, asphaltene inhibitors, paraffin inhibitors, water clarifiers and biocides in an integrated way
- Essential to consider Conditions – Compatibility depends on salinity/composition of water and temperature and hydrocarbon composition….
- Aim to minimize chemical use, but care needed to understand the effects of over/under dosing, compatibilities and performance synergies as relative product concentrations can vary
- Proprietary nature of some chemicals should not hamper good compatibility testing of the products as applied
- Local independent labs in the Midland area may be able to perform pre-screening tests needed before any attempt to trial products in the field is undertaken
- Small scale field trial pilot key to minimizing any downside production and revenue risks
- Stepwise approach will save wasted time and effort as well as potentially reduce the risk of solids deposition, process upsets and ‘dirty water’ requiring re-processing

Highest value learnings for Permian?

- Can Frac Pack Scale Inhibition protect Permian wells over life of field ?
- Can the scale related analysis maximise local analysis and existing local infrastructure and new field test methods ?
- Can we develop a business model to facilitate enhanced scale squeeze technologies ?
- Can we optimise our inhibitor qualification for our whole chemical suite for the specific needs of the Permian ?
- Can we de-risk water compatibility for re-use and transportation ?
- Can we minimize interventions and compatibility to reduce costs, and impacts on our local community?
- Are there any further lessons we can learn globally on local environmental challenges e.g. road damage, seismic activity, air quality, subterranean water trespass etc. ?

Highest value learnings for Permian?

….The Future is Challenging but we will maximize value by working together, moving forward, learning from the past and applying lessons carefully with regard to the specific Permian conditions and challenges….

Questions?