Overview of Offshore Well Completions

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NASEM Workshop: Offshore Well Completion and Stimulation using Hydraulic Fracturing and Other Technologies

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Contributors

• Numerous Members and Associate Members of the Offshore Operators Committee contributed many staff-hours to help develop this presentation

The information contained in this document is reflective of current industry practices (as of 2017) only. Future technical developments and methods may change
Overview

• Offshore Well Completions
  • Basics
  • Techniques Utilized
• Sand Control Completion Operations
• Comparison of Offshore and Onshore Well Completions
• Summary
Reservoir characteristics drive the well completion requirements:

- **Unconsolidated sands**
  - Generally shallower & younger aged rock (Pliocene and Miocene)
  - High permeability reservoirs (Permeability and porosity are maintained at depth)
  - Requires a need to bypass near wellbore formation damage (Skin)
  - Sand control technique – gravel pack / frac pack

- **Consolidated sands**
  - Generally deeper & older aged rock (Oligocene, Eocene, Paleocene)
  - Low permeability reservoirs (Permeability and porosity are challenged at depth with increased pressure and temperature)
  - Requires inducing a near wellbore fracture for stimulation (Includes Lower Tertiary)
Offshore Well Completions: Techniques Utilized

- Primary driver of offshore completion design is sand control with an extensive history of successful application in the Gulf of Mexico:

  - Gravel / Annular Pack
    - Proppant filled perforation tunnels and screen x casing annular area
  
  - Frac Pack
    - Induces near wellbore fracture geometry that is filled with proppant to bypass near wellbore damage and extend the proppant pack a further distance from the wellbore

  - Hydraulic Fracturing
    - Technique used for reservoir stimulation in consolidated reservoirs
Offshore Completion Techniques: Unconsolidated Sands – Historical

- Traditional sand control
- Long standing practice – 50+ years
- Historically, represented ~100% of GoM sand control completions
- Currently, < 10% because technology has evolved
- Water, brine or gelled brine as a carrier fluid
- Only treats annulus and / or near-wellbore area and packs the annulus for sand control
- Significantly reduces amount of sand that flows into well bore
- Limits plugging and reduces frequency of maintenance operations on well bore
- Covered by existing regulations / permits
Offshore Completion Techniques: Unconsolidated Sands – Current

- Long standing practice – 25+ years
- Currently, >75% of GoM treatments
- Gelled water or brine as carrier fluid
- Induces fracture to create tighter proppant pack but is not designed for significant stimulation like hydraulic fracturing
- 10 - 60 ft. fracture half-lengths
- Typically < 500 bbls proppant volume
- Bypasses near-wellbore damage; extends sand proppant pack further distance from wellbore
- Packs the annulus in a tighter manner than traditional gravel pack
- Allows for higher reliability
- Reduces well-intervention / sidetracks as compared to conventional sand control
- Covered by existing regulations / permits
Offshore Completion Techniques: Consolidated Sands – Current

- Technique has been practiced onshore for decades
- Utilized offshore for ~10 years
- Currently, < 10% of GoM treatments
- 200 – 500 ft. fracture half-lengths (“wings”)
- Typically > 500 bbls proppant volume / frac stage (2-5 frac stages/well) *
- Driven by reservoir characteristics (requirement for reservoir stimulation as well as fracture orientation and size)
- Minimizes the number of wellbores required to develop the resource (less environmental impact)
- Allows development of natural resources previously not commercially viable (improved production rates and faster return on investment)
- Discharge footprint same order of magnitude as frac pack
- Covered by existing regulations / permits

* Volumes could vary based on reservoir properties
Sand Control Completion Operations: General Step-by-Step

- First, gel and water are blended together
  - Typically use quality guar, starch or cellulose gel
    - many gel powders are found in commercial foods & commodities (ice cream, gravy, ketchup, cosmetics, etc.)
    - this mixture is referred to as frac gel and is viscous like vegetable oil
- Second, proppants are blended into the gel in a large blender that mixes the ingredients
  - Additives include cross-linkers, surfactants and buffers
- Finally, the resulting mixture becomes a cross-linked fluid that behaves like Jello®
Sand Control Completion Operations: General Step-by-Step (cont’d)

- Mixture is pumped downhole, where the gelatin-like fluid transports proppant into the created fracture
- Fracture becomes filled with proppant, and pumping is ceased
- Additives in the fluid system break the cross-link, turning the Jello® like fluid back into a liquid
- Fracture closes on proppant trapping it in place, and fluid flows out of the well during production
Sand Control Completion Operations: General Step-by-Step (cont’d)

- The proppant provides a highly conductive channel to allow reservoir fluids to move easily toward the wellbore, which enhances the well productivity.

- Routinely utilize **mini-fracs** (gelled fluid without proppant) to gain information about the reservoir to help design the main treatment:
  - Mini-fracs are followed by mini-frac flush fluid to prepare well for main treatment.
# Relative Comparison of Well Treatment Volumes

<table>
<thead>
<tr>
<th>Type</th>
<th>Offshore Conventional</th>
<th>Onshore Unconventional</th>
<th>Offshore Fluid Description</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Example Volume (bbls)</td>
<td>Example Volume (bbls)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Unconsolidated (conv sand control &amp; frac pack)</td>
<td>Consolidated (hydraulic fracturing)</td>
<td></td>
</tr>
<tr>
<td>Other fluids assoc. with Well Completion (non-frac)</td>
<td>1,500-7,000</td>
<td>1,500-7,000</td>
<td>1,500-7,000</td>
</tr>
<tr>
<td>Mini Frac</td>
<td>500-700</td>
<td>500-700</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Mini Frac Flush</td>
<td>500-800</td>
<td>500-800</td>
<td>Not Applicable</td>
</tr>
<tr>
<td>Main Treatment</td>
<td>&lt; 5,000</td>
<td>&gt; 5,000 per stage (2 – 5 stages)</td>
<td>&gt; 30,000 per stage (&gt; 10 stages)</td>
</tr>
<tr>
<td>Main Treatment Flush</td>
<td>500-800</td>
<td>500-800</td>
<td>200-500</td>
</tr>
</tbody>
</table>

Note: Example volumes are variable and are based on reservoir properties in each respective environment
**Well Completion Comparison**

### Technologies used *Onshore*
- **Primary driver**
  - formation stimulation
  - create fractures in tight rock
- **Unconsolidated sands**
  - gravel pack
  - frac pack
  - acid stimulation
- **Consolidated sands**
  - acid stimulation
  - conventional hydraulic fracturing
- **Shale (unconventional resources)**
  - high volume hydraulic fracturing

### Technologies used *Offshore*
- **Primary driver**
  - formation stimulation
  - sand control
- **Unconsolidated sands**
  - gravel pack
  - frac pack
  - acid stimulation
- **Consolidated sands**
  - acid stimulation
  - conventional hydraulic fracturing
Offshore Well Completions: Summary

• Primary driver of offshore completion design is sand control with an extensive history of successful application in the GoM
• Offshore completion activities are covered extensively by existing regulations – both operational & environmental
• High volume hydraulic fracturing of unconventional formations is not occurring offshore GoM
• Concerns for implications to drinking water aquifers is not pertinent to offshore operations
• Remoteness of operations ensures minimal, if any, public impacts from completion activities