Sand Control Fundamentals

Virtual Instructor Led
Session #2

Non-Gravel Pack Applications

Slotted liners and screens in a non-gravel pack are FILTRATION DEVICES
Except for Expandable Screens (but may also be a good option)
Horizontal Well Gravel Pack Completions

- Horizontal wells allow significantly more reservoir access compared to vertical wells
- More access results in significantly higher well productivity
- Sand production is normally decreased because of lower fluid flux rates
- However, sand control is often required in horizontal wells
- Stand-alone screens can be used in formations that are uniform
- However, in non-uniform formations, screens plug over time, and “hotspots” lead to early screen failures

Horizontal Well Gravel Packing

- Long horizontal wells can be successfully gravel packed using:
  - Brine carrier fluids
  - Gel carrier fluids (with alternate path technology)
  - In Cased-hole completions
  - In Open-hole completions

- Fracpacks can also be successfully placed in Horizontal Well

- Stand-Alone Screens (SAS) can be used (no gravel pack) but only in uniform sands

- Expandable Sand Screens (ESS) have been used to control sand production
Gravel Placement in Horizontal Wells with Brine

Can completion and tight packing of the whole section be achieved in long extended length holes? With proper design and equipment, the answer is...Yes.

Horizontal Open Hole Gravel Pack

Alpha and Beta Wave Principle

Increased Friction During Beta Wave
Screen
Wash Pipe
Open Hole
Can completion and tight packing of the whole section be achieved in long extended length holes?
Not without additional equipment – Gels require the use of Alternate Path Technology
However, with proper design and equipment, the answer is... Yes

Alternate Path Shunt Tube Configuration

**Shunt Tube Tool**
- Alternate slurry path
- Ports every 3 ft (0.9 m)
Sources of Gravel Packing Problems

- Damage from drilling fluid invasion
- Dirty gravel placement fluids
- Improper gravel size
- Insufficiently packed perforations plugged by formation particles
- Gravel crushed or mixed with formation sand
- Brine - Tanks - Not - Clean
- Gravel sized incorrectly
- Gravel does not meet API Specifications
- Fluid loss control materials placed in perforations when pulling guns

Benefits of Prepacking with Perforating Guns in Hole

- Eliminate possible need for placing fluid-loss control material into empty perforations.
- If fluid loss control is needed it can be placed inside casing, allowing easier cleanup.
- Extra trip with packer/tailpipe assembly is eliminated.
- Dedicated prepacking operation is still possible.
Darcy's Law for Radial Flow (Oilfield Units)

**Steady State**

\[ q_o = \frac{0.00708 k h (P_r - P_{wf})}{\mu_o B_o \left( \ln \left( \frac{r_e}{r_w} \right) + S \right)} \]

**Semi-Steady State**

\[ q_o = \frac{0.00708 k h (P_r - P_{wf})}{\mu_o B_o \left( \ln \left( \frac{r_e}{r_w} \right) - 0.75 + S \right)} \]

0 or negative value for best well productivity

* In oilfield units

Importance of Clean Tubulars and GP Equipment

- Clean tubing before setting packer (pickle tubing)
  - Acid
  - Solvent
- Apply pipe dope moderately on pin only
- Check that gravel pack completion equipment is not painted
- Check that equipment is free of rust, mill scale, acidizing and cementing materials
- Check that fluids storage containment is thoroughly cleaned before mixing completion fluids
API RP 58 Gravel Quality Specifications

- Sieve analysis
  - Less than 0.1% oversized and less than 2% undersized
- Sphericity and Roundness
  - Average sphericity and roundness of 0.6
- Acid solubility
  - Less than 1% soluble in 12/3 HF-HCl mud acid
- Silt and Clay Content
  - Turbidity NTU reading lower than 250
- Crush resistance
  - Less than 2% fines created by 2,000 psi (13.8 mPa) confining stress

Gravel-Packing Recommendations

- Each step must be done “By the Book”
- This yields:
  - The lowest skin,
  - The best production, and
  - The fewest amount of workovers required
Darcy’s Law Calculation
Problem 2

What production rates would be predicted for a 7-inch (17.8 cm) diameter, gravel-packed cased-hole completion? The formation Permeability is 100 md, the reservoir height is 50 ft (15.2 m), a delta P of 1,000 psi (6895 kPa), a formation volume factor of 1, and fluid of 3 cp.

Calculate the expected flows for a skin of 0, and for a skin of 8. The wells are on 40 acre spacing, i.e., drainage radius = 660 ft (201.2 m).
ESS® – Expandable Sand Screens

- Eliminates annular space of a conventional liner run in hole which is a possible erosion site
- Virtually no annulus after expansion
- Conventional liner completion with annulus
- Now Available from several service companies

ESS® – Expandable Sand Screens

- Remedial Sand Control capability - reduced workover costs
- Optimized O.D. / I.D. ratios – maximized flow conduit, minimized well costs
- Reduced erosion potential
- Reduced ΔP – optimized productivity
- Borehole stabilization
- Sand Control for slimhole/ slender wells

Example shown: 8-½" (21.6 cm) O.D. Post Expansion
Hydraulic Fracturing

- This sand control technique is basically a combination of fracturing the formation, and installing a sand control completion, all in the same operation.

FracPack Completions

- Prepacking the perforations above frac pressure
- Gravel pack screen completion equipment in place
- Gravel / proppant pumped to fill fracture created
- Enhanced rate, longer lifetime, and sand protection control
FracPack Completions

- Propped hydraulic fracture stimulation using tip screen-out fracturing techniques, conducted prior to or as part of gravel packing
- This is usually done with gravel pack screens and packer-crossover tool assembly in place
- Allows gravel packing after frac job in a single, continuous pumping operation
- The proppant used must be strong enough to withstand the closure stress of the fracture. This often requires manmade proppants.

A FracPack Completion

- Proppant Filled Fracture
- Cement
- Casing
- Screen
- Gravel Filled Perf Tunnel
- Damaged Formation
Hydraulic fracture is created and then grows as pad is pumped.

Start pumping in gravel, and it starts filling fracture.
Tip Screen-Out Fracture Concept

As carrier fluid leaks into formation, immobilization of proppant (or screenout) at fracture tip arrests fracture extension.

Tip Screen-Out Fracture Concept

Since proppant can’t move, continued pumping expands frac width and increases proppant loading in frac.
Tip Screen-Out Fracture Design

Net Pressure Plot (Log Net P vs Log Time)

Fracture is packed and pumping stops

Net Pressure = Treating Pressure – Fracture Closing Pressure

FracPack Results

- Typical skin value for fracpacked well: -2 to +3
- Fracpacks often result in 3 to 4 times more production compared to a conventional cased-hole gravel pack
- Longevity / gravel pack well life often very good
- Fines migration is often completely eliminated
### Typical Pump Schedule for FracPack

<table>
<thead>
<tr>
<th>SLURRY VOLUME, gal (m³)</th>
<th>FLUID VOLUME, gal (m³)</th>
<th>PROPPANT CONCENTRATION, lb/gal (kg/l)</th>
<th>PUMP RATE, BPM (m³/min)</th>
<th>PUMP TIME (min)</th>
</tr>
</thead>
<tbody>
<tr>
<td>3,000 (11.4)</td>
<td>3,000 (11.4)</td>
<td>0</td>
<td>15 (2.38)</td>
<td>4.76</td>
</tr>
<tr>
<td>6,140 (23.2)</td>
<td>6,000 (22.7)</td>
<td>0.5 (0.06)</td>
<td>15 (2.38)</td>
<td>9.74</td>
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<tr>
<td>4,180 (15.8)</td>
<td>4,000 (15.1)</td>
<td>1.0 (0.12)</td>
<td>15 (2.38)</td>
<td>6.64</td>
</tr>
<tr>
<td>4,365 (16.5)</td>
<td>4,000 (15.1)</td>
<td>2.0 (0.24)</td>
<td>15 (2.38)</td>
<td>6.93</td>
</tr>
<tr>
<td>3,410 (12.9)</td>
<td>3,000 (11.4)</td>
<td>3.0 (0.36)</td>
<td>15 (2.38)</td>
<td>5.41</td>
</tr>
<tr>
<td>2,960 (11.2)</td>
<td>2,500 (9.5)</td>
<td>4.0 (0.48)</td>
<td>15 (2.38)</td>
<td>4.69</td>
</tr>
<tr>
<td>3,180 (12.0)</td>
<td>2,500 (9.5)</td>
<td>6.0 (0.72)</td>
<td>15 (2.38)</td>
<td>5.05</td>
</tr>
<tr>
<td>2,730 (10.3)</td>
<td>2,000 (7.6)</td>
<td>8.0 (0.96)</td>
<td>15 (2.38)</td>
<td>4.33</td>
</tr>
<tr>
<td>2,180 (8.3)</td>
<td>1,500 (5.7)</td>
<td>10.0 (1.20)</td>
<td>15 (2.38)</td>
<td>3.47</td>
</tr>
<tr>
<td><strong>32,140 (121.7)</strong></td>
<td><strong>28,500 (107.9)</strong></td>
<td><strong>51.02</strong></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**NOTE:** JOB DESIGNED FOR 80,000 LBS (36,287 kg) OF 20/40 PROPPANT.
Screenless Frac Packs

- Wells can also be frac packed without screens
- Usually resin-coated proppant will be used to hold the proppant inside the fracture (to prevent proppant flowback)
- Alternatively, resin can be pumped into the proppant at the end of the job
- One major advantage is that the wellbore is left fully open for a larger flowpath

Screenless Frac Pack (Resin-Coated Gravel)

- Resin-coated gravel placed above frac pressure.
- Gravel is allowed to set up (temperature plus catalyst), and then the wellbore is drilled out.
- All perfs must be filled with resin-coated proppant.
- Cyclic loading can weaken proppant pack.
- Risk of premature failure, due to proppant flowback.
FracPacking Horizontal Wells

- Many operators are placing fracpacks in highly deviated and horizontal wells
- Multiple fracpacks may be placed in horizontal wells
- With multiple fracpacks, well productivities are very high

Sand Control Design Problem 3
The well described in the next slide has been drilled and cased down to the top of the upper zone.

The rig is still on site.

An Exploratory well was drilled into a new area, and the reservoir has the following characteristics:

- The top of the reservoir is at 4,550 ft (1,387 m), it is normally pressured. The reservoir has the lowest permeability at the top, where it is weakly consolidated. There is a sandy shale streak, about 15 feet (4.6 m) in thickness, and the extent of the shale is unknown. The oil is an API 30°, the uniformity coefficient for both formations is 3.5, and the bottom-hole temperature is 135°F (57.2°C). The median sand size for the top zone \(d_{50}\) is 0.006 inches \((0.0152 \text{ cm})\), and for the lower zone \(d_{50}\) is 0.004 inches \((0.0102 \text{ cm})\).

- Select the best sand control method for these wells.
  - If you use a screen, select the screen type.
  - If you use gravel, select the size, type, and carrier fluid to place the gravel.
**Exploratory Well - How Would You Complete?**

- **9 5/8ths Top of Sand @ 4,550’ (1,387 m), 30° API, Strong Water Drive, UC = 3.5**

- **Shale**
  - **Normally Pressured Reservoir**
  - **Sand, 200 mD, Weakly consolidated**
    - $d_{50} = 0.006” (0.0152 cm)$
  - **Sand, 400 mD, Weakly consolidated**
    - $d_{50} = 0.004” (0.0102 cm)$
  - **Sandy Shale, Unstable, 2 mD**
- **Oil/Water Interface**
- **Sand, 400 mD**
- **Shale**

**QUESTIONS?**