SPE DISTINGUISHED LECTURER SERIES

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Selection and Design Criteria for Sand Control Screens

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Sand Control Methods

- No control
- Slotted Liner / Punched Slot Liner
- Wire-Wrapped Screen
- Pre-Packed Screen
- Shrouded Metal Mesh Screen
- Expandable Screen
- In Situ Consolidation (Resin)
- Oriented & Selective Perforating
- OHGP & IGP
- Frac Pack (Including Extension Pack or HRWP)
- Screenless Frac Pack
Screen Selection

Screens are an integral part of most downhole sand control strategies.

Common applications include:

- Stand alone (open and cased hole)
- Combined with gravel or frac packs, extension packs and HRWP
- Remedial or artificial lift protection applications
Screen Selection

Screen should be selected for maximum sand retention and minimum productivity impairment

NOTE: potentially conflicting criteria

- Formation Particle Size Distribution (PSD)
- Correct slot or micron rating (empirical methods)
- Screen Permeability
- SAND Software
- Sand Retention Tests
Screen Selection
Using Sieve Analysis Techniques

- Formation Sand Sampling
- Sieve Analysis Techniques
  - Dry Sieving
  - Laser Light Scattering (LPSA)
- Particle Size Distribution (PSD)
Screen opening (slot/micron rating) is dependent on particle size distribution (PSD)

- **Important parameters are:**
  - \(d_{50}, d_{10}, d_{90}, d_{95}, d_{40}, d_5\)  
  - Sorting Coefficient \((S_c)\) – \(d_{10}/d_{95}\)  
  - Uniformity Coefficient \((U_c)\) – \(d_{40}/d_{90}\)

- **Empirical selection criteria:**
  - COBERLY (ROGERS): 2 to 1 x \(d_{10}\) (largest 10%)
  - SAUCIER: ~ 6.5 x \(d_{50}\)
  - GILLESPI et al: \(U_c < 2\) use \(d_{50}\), \(U_c \sim 2\) use \(d_{40}\), \(U_c > 2\) use \(d_{30}\)
  - SCHWARTZ: \(U_c < 3\) use \(d_{10}\), \(U_c \sim 5\) use \(d_{40}\), \(U_c > 10\) use \(d_{70}\)
  - BALLARD AND BEARE: \(d_5\) or \(d_{10}\) of finest sand that fails

- **Semi-empirical method:**
  - SAND Software (developed by International Research Institute of Stavanger [IRIS])
Comparison of Methods for Stand Alone Screen Selection
Screen Permeability

• Any screen is permeable media through which flow penetrates under certain hydraulic conditions

• Major importance is to determine screen permeability
  ▪ True indicator of inflow capacity
  ▪ Interface with formation, not open area, which is only part of the screen structure

• Permeability is 3D; open area 2D

• Comparison criteria – Screen permeability, not % open area
Sieve Analysis data from various measured depths (right) are input into Sand Software.

Results presented in graph (below):

- Smallest slot opening where continuous sand production expected to occur.
- Largest slot opening where sand production not expected to occur.
- Smallest slot opening where no plugging is expected to occur.
- Largest slot opening where severe plugging is expected to be frequent.

“Safe” slot width range.
Correct Slot Width or Micron Rating

Many operators do not use published empirical or semi-empirical selection methods

- Coberly and Rogers - do not give reliable results
  - No accounting for sorting or uniformity of sand
- Gillespie et al, Schwartz and Ballard & Beare – better
  - Account for sand sorting and uniformity
- SAND does not work with LPSA due to high percentage of fines measured

Standard practice – perform sand retention tests with real or simulated formation sand
Sand Retention Test Methods

SLURRY TESTS
• Sand in slurry and flow onto screen
• Weigh sand passing through
• Log pressure

SANDPACK TESTS
• Place sand directly on screen and flow through sand pack
• Weigh sand passing through
• Log pressure

Piston
Retaining mesh
Sandpack

Pressure tappings
Test media disc

SPE 98308
Factors Affecting Sand Retention Tests

- Sand retention testing not easy
- Tests do not relate to real world and subject to experimental artefacts
- View results with caution
- Factors affecting test results:
  - Wetting fluid
  - Flow rate
  - Channelling
Correct Slot Width or Micron Rating

Results: Differential Pressure and % Sand Retention

<table>
<thead>
<tr>
<th>Screen</th>
<th>Retn (@ P)</th>
</tr>
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<tbody>
<tr>
<td>12/20 Prepack</td>
<td>40 %</td>
</tr>
<tr>
<td>230 Excluder</td>
<td>79 %</td>
</tr>
<tr>
<td>250 Excluder</td>
<td>46 %</td>
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<tr>
<td>12/20 Stratapac</td>
<td>70 %</td>
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</table>

<table>
<thead>
<tr>
<th>Screen</th>
<th>Retn (@ P)</th>
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</thead>
<tbody>
<tr>
<td>12/20 Prepack</td>
<td>94 %</td>
</tr>
<tr>
<td>250 Excluder</td>
<td>94 %</td>
</tr>
<tr>
<td>12/20 Stratapac</td>
<td>95 %</td>
</tr>
<tr>
<td>300µm Baker sww</td>
<td>87 %</td>
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</table>
Sand Exclusion Devices (Filters)

- Based on Slots
  - Slotted Liner
  - Punched Slot Liner
  - Wire-Wrapped Screen
- Based on Pores
  - Pre-Packed Screen
  - Shrouded Metal Mesh Screen
  - Expandable Screen
- Other
Sand Exclusion Devices (Filters)

ISO Sand Control
Screens Standard, ISO 17824

Scheduled to be sent to ballot in February 2008
ISO Sand Control Screens Standard, ISO 17824

Scope: Sand Control Screens are mechanical filtration or retention devices to:

- Provide sand retention of the gravel pack and/or formation sand
- Allow passage of fluids during well clean up, production or any stimulation activities

Products covered:

- Wire wrap screens
- Pre-pack screens
- Metal mesh screens
Slotted Liner

Straight and Keystone Slots

- Straight Slot
- Keystone Slot
Punched Slot Liner

Stainless Steel Filtration Jacket

Support Ring

Base Pipe
Wire-Wrapped Screen

- Came out in 1970s
- Advantages
  - Keystone slots
  - High manufacturing efficiency
  - Profile materials can be stainless steel
- Disadvantages
  - Inaccurate wire spacing can allow production of formation sand or plugging
  - Can be damaged when installed through doglegs, high angle and horizontal sections because of vertical orientation between wrapped wires and support rods
Wire-Wrapped Screen

**Slip-on screen jacket construction**

All forces transferred through end connections

**Tight Fit wrap-on-pipe construction**

All forces are transferred to base pipe, and screen and base pipe behave as one unit
Rod Based – Wire-Wrapped Screen

Wedge Wire (no base pipe)
Pre-Packed Screens

Dual-screen prepack  Single-screen prepack  Slim-Pak
Metal Mesh

- **Stainless steel mesh developed in 1980s**
  - Consists of base pipe, layered filtration jacket (uneven pore structure) and outer shroud
  - Less damage occurs during installation
  - Corrosion resistance of stainless steel mesh
- **Sintered (diffusion bonded) stainless steel mesh introduced in 1990s**
  - Consists of base, multi-layer sintered metal mesh jacket (uniform pore structure) and outer shroud
  - Similar damage and corrosion resistance to non-sintered
  - High pore size accuracy, even 100 μm diameter sand can be controlled
Metal Mesh

Layered with Non Uniform Pores

Sintered Laminate with Uniform Pores

Weave Patterns
Shrouded Metal Mesh Screens

- Base Pipe
- Wire-Wrapped Jacket
- Metal Mesh
- Vector Shroud

Protection Layer
Drainage Layer
Perforated Shroud
Metal Mesh Layers
Shrouded Metal Mesh – Sintered Screen

Base Pipe

Sintered Laminate Filter Media

Diffusion of Metal Molecules
## Technical Specification Summary

<table>
<thead>
<tr>
<th>Filter Mesh Weave Pattern</th>
<th>Plain Square</th>
<th>Plain Dutch</th>
<th>Plain Square</th>
<th>Plain Dutch</th>
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<tbody>
<tr>
<td>Support Screen Weave Pattern</td>
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<td>Plain Square</td>
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<tr>
<td>Nominal Filter Rating, micron</td>
<td>140 175 200 250 300 400</td>
<td>50 80 95 125 175 250</td>
<td>50 80 95 125 175 250</td>
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<tr>
<td>Number of Layers</td>
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<td>4 3 3 3 3 3</td>
<td>4 3 3 3 3 3</td>
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<td>Min. Pore, micron</td>
<td>100 125 150 180 240 240</td>
<td>40 50 65 90 150 200</td>
<td>40 50 65 90 150 200</td>
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<tr>
<td>Max. Pore, micron</td>
<td>175 225 250 320 380 400</td>
<td>70 100 120 150 250 300</td>
<td>70 100 120 150 250 300</td>
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<tr>
<td>Min. Air Permeability, Darcy</td>
<td>600 600 600 700 700 700</td>
<td>320 325 400 400 450 400</td>
<td>320 325 400 400 450 400</td>
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<tr>
<td>Min. Porosity, %</td>
<td>58 58 58 58 57 57</td>
<td>58 60 58 53 54.8 52</td>
<td>58 60 58 53 54.8 52</td>
<td></td>
</tr>
</tbody>
</table>
Shrouded Metal Mesh – Non-Sintered Screen

- Introduced in China circa 2000
- Uniform micropore weave composite jacket on base pipe
  - Special welding technique eliminates costly sintering (diffusion bonding)
  - Double-layer media and uniform pores improves performance
Shrouded Metal Mesh Screen

Stainless Steel Wool ~ 600 Darcy

Perforated Jacket

Base Pipe
Expandable Screens
Next Generation Self-Expanding Screen
Select largest slot size or micron rating possible (under confines of required retention efficiency)

Determine screen permeability if convenient

Larger open area of screen is better

Screen strength should be considered (protective shrouds, etc.)