SPE Calgary Section – October 2011

Best Practices for Multizone Isolation Using Composite Plugs

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Based on SPE Paper 142744
Plug N Perf – Multizone Isolation
Bridge Plugs vs. Frac Plugs

Bridge Plug

Frac Plug

A.K.A. “Flow Through Plug”
Global Need

Next Challenge - International Unconventional

Argentina…Neuquen Basin…774 TCF

Australia…Beetaloo Basin…23 TCF

Eastern Europe…50 basins…700 TCF?

China, Indonesia, Russia – CBM and shale
Today’s Presentation

Why Determine Best Practices?

Methodology

Selected Survey Results

Selected Best Practices

Q & A
Definition of Best Practice

A process or method…

Customary or routine…

The highest probability of success
Why Determine Best Practices?

- Optimal Process
- Risk Reduction
- Optimal Product
- Consistent Execution
Best Practices Methodology

Best Practices

Presenter’s Expertise

Power Users Experience

Industry Literature
# Selected Survey Results

## Table 1: Ratio of Positive-to-Negative Responses (P/N)

<table>
<thead>
<tr>
<th>Ratio (P/N)</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>0.3 or less</td>
<td>Very Strong Disagreement</td>
</tr>
<tr>
<td>0.4 - 0.5</td>
<td>Strong Disagreement</td>
</tr>
<tr>
<td>0.6 - 0.8</td>
<td>Mild Agreement</td>
</tr>
<tr>
<td>0.9 - 1.1</td>
<td>No Agreement</td>
</tr>
<tr>
<td>1.1 – 2.0</td>
<td>Mild Agreement</td>
</tr>
<tr>
<td>2.1 - 3.0</td>
<td>Strong Agreement</td>
</tr>
<tr>
<td>3.1 or more</td>
<td>Very Strong Agreement</td>
</tr>
</tbody>
</table>

\[ \text{Agree/Disagree} = (P/N) = \text{Ratio} \]
Definitions & Abbreviations

CP = Composite Plug
CFP = Composite Frac Plug (Flow Through)
Perf = Perforation
Stim = Stimulation or Hydraulic Fracturing
CT = Coiled Tubing
PnP = Plug and Perf
Power Users = Respondents in Industry Survey
Selected Best Practices

Product Selection

Determining the Plug Pressure Requirement

Wellsite QA/QC

Wellbore Preparation

Perforating above the CP (Composite Plug)

Special Operational Situations
Test Your PnP (Plug and Perf) Knowledge

…Trivia Question #1

Approximately how many composite plugs were run in the United States in calendar year 2010?

Is the answer…

A 60,000 – 80,000

B 100,000 – 140,000

C 160,000 – 200,000
Product Selection Criteria

Which Golf Ball do I Choose?

Objective feedback required!
### Product Selection Criteria

<table>
<thead>
<tr>
<th></th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
<th>P/N Ratio</th>
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</thead>
<tbody>
<tr>
<td>Length of exposure?</td>
<td>9</td>
<td>19</td>
<td>0</td>
<td>0.5</td>
</tr>
<tr>
<td>Combined pressure &amp; temperature rating?</td>
<td>20</td>
<td>8</td>
<td>0</td>
<td>2.5</td>
</tr>
</tbody>
</table>
## Corrosive Environments

### Elastomeric Materials < 30 days exposure

<table>
<thead>
<tr>
<th>Material</th>
<th>Temp, °F</th>
<th>H₂S Oil Base/Diesel Completion</th>
<th>Light Brine Completion</th>
<th>Bromide Completion</th>
<th>Amine Inhibitors</th>
<th>Acids Max exposure time, hrs</th>
<th>Solvents Max exposure time, hrs</th>
<th>High pH Fluids, pH &gt; 10</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nitrile</td>
<td>To 175</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>8</td>
<td>6</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>400</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>YES</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td>4</td>
<td>24 hrs.</td>
</tr>
<tr>
<td>Viton</td>
<td>To 200</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>24</td>
<td>24</td>
<td>NO</td>
</tr>
<tr>
<td></td>
<td>350</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>YES</td>
<td></td>
<td></td>
<td>NO</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Aflas</td>
<td>To 175</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>48</td>
<td>4</td>
<td>YES</td>
</tr>
<tr>
<td></td>
<td>350</td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>YES</td>
<td></td>
<td></td>
<td></td>
<td>8</td>
<td>NO</td>
<td></td>
</tr>
<tr>
<td>EPDM</td>
<td>To 500</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
<td>YES</td>
<td>YES</td>
<td>NO</td>
<td>YES</td>
</tr>
</tbody>
</table>

**Composites - H₂S, CO₂ & H₂O – blistering, disbonding, leaching**

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Best Practices - Product Selection

Optimal Product

- Combined pressure & temperature rating.
- Require database of installations.
- Corrosive Environments - manufacturer estimates CP life
## CP Pressure Requirement

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Negative Test</th>
<th>Positive Test</th>
<th>Stimulation</th>
<th>Flowback</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSI = 7500 psi</td>
<td>PSI = 7500 psi</td>
<td>PSI = 7500 psi</td>
<td>PSI = 7500 psi</td>
<td>PSI = 7500 psi</td>
</tr>
<tr>
<td>ΔP = -9097 psi</td>
<td>ΔP = +4466 psi</td>
<td>ΔP = +3172 psi</td>
<td>ΔP = -7752 psi</td>
<td></td>
</tr>
</tbody>
</table>

The 4 Scenario Method
Best Practices

CP Pressure Requirement

CP - calculate using 4 Scenario Method.

CFP - positive test, zonal stimulation scenarios.
<table>
<thead>
<tr>
<th>Documentation Required</th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
<th>P/N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Electric line setting tool servicing records?</td>
<td>22</td>
<td>5</td>
<td>1</td>
<td>4.4</td>
</tr>
<tr>
<td>Traceability - size, part number, serial number?</td>
<td>18</td>
<td>9</td>
<td>1</td>
<td>2</td>
</tr>
<tr>
<td>Plug dimensions?</td>
<td>23</td>
<td>5</td>
<td></td>
<td>4.6</td>
</tr>
<tr>
<td>Pre-run checks - plug, setting tool, CCL?</td>
<td>23</td>
<td>4</td>
<td>1</td>
<td>5.8</td>
</tr>
</tbody>
</table>
Wireline setting / CCL tools – redress – Document!

CP – Document Everything!

Brand…style…rating…color

Dimensions

Traceability markings

Condition before RIH
Best Practices - Wellsite QA/QC

Consistent Execution

- Operators – drive this process - information & format
- Check lists – manufacturer or service company.
- Archive all available CP information
Test Your PnP Knowledge

...Answer to Trivia Question #1

Approximately how many composite plugs were run in the United States in calendar year 2010?

The answer is...

A  60,000 – 80,000

B  100,000 – 140,000

C  160,000 – 200,000
Wellbore Prep – Survey Results

Power Users - wellbore preparation is a success factor

**Bottom line** … avoid sand in casing!

Rigid, Impermeable Steel Casing - **tight** grip and seal

Soft, Permeable Sand - **poor** grip and seal
Options for Clean Wellbore

Begin with End in Mind
Avoid Flowback Between Stages
Size the flush to aid cleaning

Pump-Down Method
Intrinsic Advantage
Flow pushes sand ahead of CFP

Coiled Tubing (CT)
Remove debris between stages
CT setting tools remove debris
Best Practices - Wellbore Preparation

Optimal Process

- Execute stimulation job to prevent debris
- Avoid flowback between stimulations
- Pump-down method - intrinsic advantage
- Coiled tubing - if flowback between stages is used
<table>
<thead>
<tr>
<th>Q.</th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
<th>P/N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perforate at least 75 ft. above plug?</td>
<td>8</td>
<td>15</td>
<td>4</td>
<td>0.5</td>
</tr>
<tr>
<td>Perforate at least 100 ft. above plug?</td>
<td>9</td>
<td>14</td>
<td>4</td>
<td>0.6</td>
</tr>
<tr>
<td>Use Shock-wave software to determine safe perforating distance?</td>
<td>7</td>
<td>7</td>
<td>13</td>
<td>1</td>
</tr>
<tr>
<td>Use field experience and shock-wave software (S/W)?</td>
<td>15</td>
<td>4</td>
<td>7</td>
<td>3.8</td>
</tr>
</tbody>
</table>
Shockwave Simulation Using S/W

Sample Simulation Using 5 ½” CP
When CP Fails During Perforating

Big $$$ Problem

Plug Fails When Perforating

Frac Fluids in Wrong Zones
Best Practices - Perforating Above CP

- Shock wave intensity ↑ gun length, rock stiffness, etc.
- Simulate, then compare to plug rating
- Pressure wave is bigger problem for CPs.
- When possible, use software to make the decision
### Special Operational Situations

<table>
<thead>
<tr>
<th>Is This a Best Practice?</th>
<th>Risk</th>
<th>Yes</th>
<th>No</th>
<th>Don’t know</th>
<th>P/N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tag plug with setting tool</td>
<td>Stuck setting tool</td>
<td>15</td>
<td>13</td>
<td></td>
<td>1.2</td>
</tr>
<tr>
<td>Low fluid level wells</td>
<td>Damage plug</td>
<td>20</td>
<td>8</td>
<td></td>
<td>2.5</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Is This a Best Practice?</th>
<th>Yes</th>
<th>No</th>
<th>Don’t Know</th>
<th>P/N Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>Set plug in perforated casing joint?</td>
<td>14</td>
<td>10</td>
<td>4</td>
<td>1.4</td>
</tr>
<tr>
<td>Set plug where packer had been removed?</td>
<td>14</td>
<td>9</td>
<td>5</td>
<td>1.6</td>
</tr>
</tbody>
</table>
Tagging Plug with E-Line Setting Tool

Assume 5 ½” 20 ppf casing (ID = 4.778) & test pressure = 10,000 psi

ID area of casing = 17.93 in.²

17.93 in.² x 10,000 psi = 179,300 lbs.-force

Setting tool + CCL + perf gun = 500 lbs

Partially set plug resists with 2,000 lbs.-force!

Conclusion: 500 lbs. vs. 179,300 lbs. is NOT a valid test

Risk: Stuck E-Line tools and fishing job

Solution: Use a pressure test will confirm proper set
Casing Irregularities

Plug Set in Casing Collar, Perforated, or Drilled-In casing joint ...

Void at Collar

Void Compromises Rubber Seal

Same result...Any gross discontinuity in casing compromises plug
Best Practices
Special Operational Situations

“Problem Casing”

- Avoid collars, perforated or drilled-in casing

⇒ Use pressure test to assess plug condition
Review
Plan for Success & Minimize Risk

1. Pick the right product.
2. Avoid over-pressuring the plug.
3. Emphasize documentation.
4. Prepare the Wellbore.
5. Perforate for Plug Survival.
6. Avoid “Special Operational Situations”.
Thank You!

Thanks to the Management of ConocoPhillips & Baker Hughes who provided support for SPE 142744.

Questions & Answers