Proppant Erosion During Fracturing: From Wellhead to Perforations

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AUTHOR: George E. King, P.E. Apache Corporation
Proppant Erosion Factors:

Shape, Size, Density, Amount, Velocity, Impact Angle, Proppant Hardness

<table>
<thead>
<tr>
<th>Proppant Type</th>
<th>Specific Gravity (g/cc)</th>
<th>Mohs Hardness</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand</td>
<td>2.6</td>
<td>~7</td>
</tr>
<tr>
<td>Resin Coated Sand (RCS)</td>
<td>2.65</td>
<td></td>
</tr>
<tr>
<td>Light Weight Ceramic (LWC)</td>
<td>2.7</td>
<td>~6.4</td>
</tr>
<tr>
<td>Intermediate Strength Ceramic (ISP)</td>
<td>3.3</td>
<td>~8.2</td>
</tr>
<tr>
<td>Sintered Bauxite</td>
<td>3.6</td>
<td>~9</td>
</tr>
</tbody>
</table>
Proppant Erosion Factors:

Proppant Source

Figure 5—Comparison of normalized erosion rates between source A and source B for each type of proppant.
Proppant Erosion Factors:

Proppant Concentration and Velocity

![Graph showing normalized erosion rate vs. proppant concentration and fluid velocity.](image-url)
Proppant Erosion Factors

Target Hardness

<table>
<thead>
<tr>
<th>Pipe Grade (Min. Yield)</th>
<th>HRC at Min Yield</th>
<th>Higher Yield HRC</th>
</tr>
</thead>
<tbody>
<tr>
<td>L-80</td>
<td>23 max</td>
<td></td>
</tr>
<tr>
<td>P-110</td>
<td>30 max</td>
<td>36+</td>
</tr>
<tr>
<td>Q-125</td>
<td>36 max</td>
<td></td>
</tr>
</tbody>
</table>

If proppant was measured on HRC scale – would go from HRC 50 to HRC 80.

Harder pipe may have drawbacks in corrosion.
Proppant Erosion Factors

Wellhead

Eroded up-looking pin about 6 feet below the surface.

Side outlets in wellhead

Erosion grooves directly under outlets - swirl pattern

Side Outlets
Erosion Factors – Velocity and Direction Change

Frac Packing – an Extreme Erosion Situation

Velocities of up to 200 ft/sec at exit.

Fig. 7: Baseline Testing Results of the Bypass Crossover Sub, Packer Extension, and Casing at 40 bbl/min  SPE 102029
Velocities as fluid direction changes from down the pipe into the fracture.
Multiple Strings? – What Effect?

5-1/2” x 7” x 13-3/8” (unrealistic spacing)
Very closely spaced strings – much easier, but still an issue – Erosion probably won’t be seen in the outer strings.

5-12” x 9-5/8” x 13-3/8”
Difficult for Any Perforator

Not much damage to the cement.
Proppant Erosion at Joint – also a problem.
Erosion - Corrosion

• Small gaps cause big problems in high rate flow.

Production – lower rate, long term
Injection – high rate (+solids), short term

Left: erosion in a well head after several fracture treatments.

Right: progressive erosion of the down-looking pin at high production rate.
Erosional Coupling Damage

This is classic downwards flow erosion – note the undamaged upper pin end.
Caliper 3-D View

The reason these logs were important

What we saw

Well Joint after 17 fracs
54,400m³ H₂O / 3,400t Sand
16m³/min

example of measurable erosion
DF-70-J

Erosion below ports in well head

Coupling 1

Coupling 2
Erosion most serious in the upper couplings – just under the wellhead.
2600 feet down.
Conclusions

• Erosion is variable – many factors affect the outcome
  • Proppant – angularity, size, density, concentration
  • Pump Rate – velocity
  • Well design – direction changes, gaps, ports
  • Pipe - Casing hardness, diameter, depth

• Horizontals – Settling?
• Flow back – First few days critical
• Heel vs. Toe – Damping mechanisms
QUESTIONS? THANK YOU

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