Is Just Good Enough
Conductivity Still Good Enough
When it Gets Dirty?

Ray Ellis: Regional Technology Manager, Liberty Energy
Resources

• SPE 199751, *Shale Frac Designs Move to Just-Good-Enough Economics*
  • Howard Melcher, Mike Mayerhofer, Karn Agarwal, Ely Lolon, Oladapo Oduba, Jessica Murphy, Ray Ellis, Kirk Fiscus, Leen Weijers – Liberty Oilfield Services, Robert Shelley – RF Shelley LLC

• Stimlab Proppant Consortium ongoing research
  • Barry Hlidek, Lisa O’Connell, Bob Duenckel
Where and What

• Proppant Trends/Big Data Review

• Minimum required conductivity
  • Eagle Ford Play
  • Permian Basin

• Turbidity effects
Where We Were

Where We Are
Closer to Home

Northern White

Texas Dune
Where are we Heading?

Normalized Completion Parameters by Basin

- Stage Spacing (ft/Stage)
- Max Rate/Stage Length (bpm/ft)
- Total Clean Volume/Lat. Length (bbl/ft)
- Proppant Mass/Lat. Length (ton/ft)

Year of Production Start Date: 2010 to 2022

Basin:
- WILLISTON
- POWDER RIVER
- DJ
- EAGLE FORD
- PERMIAN

Average
# Honey, I Shrank the Sand!

## Proppant Size by Basin

<table>
<thead>
<tr>
<th>Avg. % 20/40</th>
<th>WILLISTON</th>
<th>POWDER RIVER</th>
<th>DJ</th>
<th>PERMIAN</th>
<th>EAGLE FORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>0%</td>
<td>14%</td>
<td>4%</td>
<td>1%</td>
<td>0%</td>
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</table>

<table>
<thead>
<tr>
<th>Avg. % 30/50</th>
<th>WILLISTON</th>
<th>POWDER RIVER</th>
<th>DJ</th>
<th>PERMIAN</th>
<th>EAGLE FORD</th>
</tr>
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<tbody>
<tr>
<td>0%</td>
<td>15%</td>
<td>38%</td>
<td>1%</td>
<td>3%</td>
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</table>

<table>
<thead>
<tr>
<th>Avg. % 40/70</th>
<th>WILLISTON</th>
<th>POWDER RIVER</th>
<th>DJ</th>
<th>PERMIAN</th>
<th>EAGLE FORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>46%</td>
<td>17%</td>
<td>40%</td>
<td>16%</td>
<td>8%</td>
<td></td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Avg. % 100 Mesh</th>
<th>WILLISTON</th>
<th>POWDER RIVER</th>
<th>DJ</th>
<th>PERMIAN</th>
<th>EAGLE FORD</th>
</tr>
</thead>
<tbody>
<tr>
<td>29%</td>
<td>39%</td>
<td>15%</td>
<td>51%</td>
<td>61%</td>
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</table>

<table>
<thead>
<tr>
<th>Year</th>
<th>WILLISTON</th>
<th>POWDER RIVER</th>
<th>DJ</th>
<th>PERMIAN</th>
<th>EAGLE FORD</th>
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<tbody>
<tr>
<td>2022</td>
<td>46%</td>
<td>17%</td>
<td>40%</td>
<td>16%</td>
<td>8%</td>
</tr>
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<td>29%</td>
<td>39%</td>
<td>15%</td>
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</tbody>
</table>
How Low Can We Go?
Is Regional Sand a Better Value? Maybe Not

Eagle Ford - Results

Cumulative Oil Production

Net Present Value
Or Maybe So!
Permian, Lower Spraberry - Results

**Cumulative Oil Production**

**Net Present Value**
Now Let’s Add Some Friction Reducer
Certainly, Time and Temperature Will Make it Better

2,000 psi Closure Stress at 180°F with 3 gal/1000 GFR-1 and No Breaker

Percent Retained Conductivity

<table>
<thead>
<tr>
<th>Formation</th>
<th>2000-0hr</th>
<th>2000-0.25hr</th>
<th>2000-0.5hr</th>
<th>2000-1hr</th>
<th>2000-2hr</th>
<th>2000-5hr</th>
<th>2000-10hr</th>
<th>2000-20hr</th>
<th>2000-22hr</th>
<th>2000-24hr</th>
<th>2000-25hr;180F</th>
</tr>
</thead>
<tbody>
<tr>
<td>40/70 Santa Rita do Passa Quatro Formation</td>
<td>28</td>
<td>68</td>
<td>76</td>
<td>79</td>
<td>81</td>
<td>81</td>
<td>80</td>
<td>79</td>
<td>78</td>
<td>84</td>
<td>22</td>
</tr>
<tr>
<td>50/140 Paluxy Formation</td>
<td>28</td>
<td>66</td>
<td>71</td>
<td>73</td>
<td>74</td>
<td>76</td>
<td>76</td>
<td>75</td>
<td>72</td>
<td>77</td>
<td>11</td>
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<tr>
<td>70/140 Wonewoc Formation</td>
<td>28</td>
<td>66</td>
<td>68</td>
<td>68</td>
<td>70</td>
<td>67</td>
<td>66</td>
<td>61</td>
<td>59</td>
<td>68</td>
<td>18</td>
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<tr>
<td>100/400 Dune Sand #5</td>
<td>28</td>
<td>72</td>
<td>66</td>
<td>66</td>
<td>68</td>
<td>68</td>
<td>61</td>
<td>18</td>
<td>11</td>
<td>22</td>
<td>11</td>
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</table>
Breaker, The Universal Cure, Right?

API Conductivity Cell Clean-up
70/140, 180°F

Breaker- 2 ppt AP
Bring On the Dirt

• API STD19C defines turbidity as the following:
  • “Turbidity tests measure an optical property of a suspension that results from the scattering and absorption of light by the particulate matter suspended in the wetting fluid”
  • Essentially-The opacity of the total suspended solids in a suspension after 5 minutes of settling time
• Particle Settling Rate is driven by:
  • Size
  • Density
  • Mineralogy
  • Shape
• Max Allowed – 250 NTU

• Common values today...
  • To Infinity and Beyond!
Everything’s Big in Texas
200 Mesh Texas Dune Sand, Winkler County, Texas

Dune Sand, Winkler County, TX 200 Mesh, Turbidity Fines

<table>
<thead>
<tr>
<th>Component</th>
<th>Percentage</th>
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<tbody>
<tr>
<td>Quartz</td>
<td>51.9</td>
</tr>
<tr>
<td>Plagioclase</td>
<td>12.1</td>
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<tr>
<td>K-feldspar</td>
<td>9.6</td>
</tr>
<tr>
<td>Pyrite</td>
<td>0.9</td>
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<tr>
<td>Halite</td>
<td>0.7</td>
</tr>
<tr>
<td>Illite/Mica</td>
<td>11.6</td>
</tr>
<tr>
<td>Illite/Smectite</td>
<td>11</td>
</tr>
<tr>
<td>Kaolinite</td>
<td>2.2</td>
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</tbody>
</table>

~450 Mesh
442 NTU
How Bad Could a Little Dirt Be?

Conductivity 30/140 Texas Regional Sand-461 NTU Turbidity vs 2.6 NTU Turbidity

71 – 14% Difference
Maybe We Can Crush it Out of Existence
To Bathe, Or Not to Bathe…?
50/140 Alluvial, Howard County, TX

Percent Retained Conductivity (Internal Control) with
2% KCl of 1 lb/ft² of 50/140 Unwashed vs Washed
And Sized Regional Sand (Porosity Injected Frac Fluid)
At 2000 psi Closure Stress at 180°F between Ohio Sandstone
So...What Difference Does it Make?
Impact of 50% Damage on Model Production

LWR Spraberry (10% Loss)  
Eagle Ford (3% Loss)
My Sand is Clean…But…

GFR4

Viscosity at 100 sec $^{-1}$ cp

High TDS – 10cp (190k TDS)
Fresh Water – 25cp