3M™ Glass Bubbles in Drilling Fluids Applications

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Low Density Drilling Fluids with 3M™ Glass Bubbles

Ideal for use near balance, at balance or underbalance drilling applications in:

- Depleted reservoirs
- Geologically-fractured formations
- Poorly-consolidated formations
- High-permeability formations

In general, reduction of differential pressure can result in:

- Higher productivity through increased rate of penetration (ROP)
- Elimination of differential sticking
- Reduction or elimination of fluid loss/lost circulation
- Reduction of formation damage
Low Density Drilling Fluids with 3M™ Glass Bubbles

Offer the potential to reduce costs and improve performance

- 3M™ Glass Bubbles successfully and predictably reduce the density of drilling fluid
- Drilling fluids with 3M™ Glass Bubbles are homogeneous, incompressible, stable and allow measurement while drilling (MWD)
- They provide good borehole stability and excellent hole cleaning
- They can survive demanding downhole conditions
- They also help ease the pressure on rig footprint and personnel – always an issue offshore or at remote inland locations
By adding 3M™ Glass Bubbles you can prepare a single phase incompressible drilling fluid with density as low as 5.5 ppg.
Aerated Fluids Concerns

In spite of the benefits gained by overcoming overbalance conditions, several concerns exist with aerated fluids:

- Aerated fluids are compressible
- Hydraulic calculations complex
- Drill string vibration
- Friction and torque increase
- Cuttings lift loss efficiency
- Signal attenuation while drilling
- May compromise well stability
- Corrosion issues
- Fire/explosion issues
- Cost of technique – Specialized Resources

Low Density Drilling Fluids with 3M™ Glass Bubbles

Provide an alternative to Aerated Fluids

- An innovative alternative to produce low density drilling fluids by incorporating 3M™ Glass Bubbles into conventional drilling fluids
- 3M™ Glass Bubbles can be added to virtually any type of existing mud system
- Allow usage of standard mud handling equipment
- Can survive demanding downhole conditions
- Will not adversely affect the rheology of a fluid
- Can help lubricate the drillstring and reduce casing wear
## 3M™ Glass Bubbles – Engineered Material

### Density

<table>
<thead>
<tr>
<th>Product</th>
<th>Typical</th>
<th>True Density (g/cc)</th>
<th>Minimum</th>
<th>Maximum</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGS2000</td>
<td>0.32</td>
<td></td>
<td>0.29</td>
<td>0.35</td>
</tr>
<tr>
<td>HGS3000</td>
<td>0.35</td>
<td></td>
<td>0.32</td>
<td>0.38</td>
</tr>
<tr>
<td>HGS4000</td>
<td>0.38</td>
<td></td>
<td>0.35</td>
<td>0.41</td>
</tr>
<tr>
<td>HGS5000</td>
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<td>0.41</td>
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<tr>
<td>HGS6000</td>
<td>0.46</td>
<td></td>
<td>0.43</td>
<td>0.49</td>
</tr>
<tr>
<td>HGS8000X</td>
<td>0.42</td>
<td></td>
<td>0.39</td>
<td>0.45</td>
</tr>
<tr>
<td>HGS10000</td>
<td>0.60</td>
<td></td>
<td>0.57</td>
<td>0.63</td>
</tr>
<tr>
<td>HGS18000</td>
<td>0.60</td>
<td></td>
<td>0.57</td>
<td>0.63</td>
</tr>
</tbody>
</table>

### Strength

<table>
<thead>
<tr>
<th>Product</th>
<th>Test Pressure (psi)</th>
<th>Target Fractional Survival</th>
<th>Minimum Fractional Survival</th>
</tr>
</thead>
<tbody>
<tr>
<td>HGS2000</td>
<td>2,000</td>
<td>90%</td>
<td>80%</td>
</tr>
<tr>
<td>HGS3000</td>
<td>3,000</td>
<td>90%</td>
<td>80%</td>
</tr>
<tr>
<td>HGS4000</td>
<td>4,000</td>
<td>90%</td>
<td>80%</td>
</tr>
<tr>
<td>HGS5000</td>
<td>5,500</td>
<td>90%</td>
<td>80%</td>
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<tr>
<td>HGS6000</td>
<td>6,000</td>
<td>90%</td>
<td>80%</td>
</tr>
<tr>
<td>HGS8000X</td>
<td>8,000</td>
<td>90%</td>
<td>90%</td>
</tr>
<tr>
<td>HGS10000*</td>
<td>10,000</td>
<td>90%</td>
<td>80%</td>
</tr>
<tr>
<td>HGS18000*</td>
<td>18,000</td>
<td>90%</td>
<td>80%</td>
</tr>
</tbody>
</table>

*Per 3M QCM 14.1.8 in glycerol.
3M™ Glass Bubbles HGS8000X

- Remain stable in a slurry mixture
- Enable a more aggressive solids control process in drilling fluids applications

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Spherical</td>
</tr>
<tr>
<td>Composition</td>
<td>Soda-lime Borosilicate Glass</td>
</tr>
<tr>
<td>Density</td>
<td>0.42 g/cc</td>
</tr>
<tr>
<td>Hardness</td>
<td>Mohs scale 5</td>
</tr>
<tr>
<td>Crush Strength</td>
<td>8,000 PSI</td>
</tr>
<tr>
<td>pH</td>
<td>9–10 in water</td>
</tr>
<tr>
<td>Soft Temperature</td>
<td>600°C</td>
</tr>
<tr>
<td>Size</td>
<td>10–100 microns</td>
</tr>
</tbody>
</table>
Formulating with 3M™ Glass Bubbles HGS8000X

Example

| Total Volume | 1000 bbl |
| Initial Density | 8.3 ppg |
| Target Density | 7.0 ppg |

3M™ HGS8000X Density

<table>
<thead>
<tr>
<th>Density</th>
<th>V/V%</th>
<th>Volume bbl</th>
<th>Weight MT</th>
<th>Weight lb</th>
</tr>
</thead>
<tbody>
<tr>
<td>Base Fluid</td>
<td>8.3</td>
<td>72.20</td>
<td>722</td>
<td>114.80</td>
</tr>
<tr>
<td>3M™ HGS8000X</td>
<td>3.51</td>
<td>27.80</td>
<td>278</td>
<td>18.56</td>
</tr>
</tbody>
</table>

| Total | 7.0 | 100.0 | 1000 | 133.36 |

<table>
<thead>
<tr>
<th>Slurry Density</th>
<th>GB Vol %</th>
<th>MT for 1000 bbl</th>
</tr>
</thead>
<tbody>
<tr>
<td>8.0</td>
<td>7.1</td>
<td>4.8</td>
</tr>
<tr>
<td>7.5</td>
<td>17.5</td>
<td>11.7</td>
</tr>
<tr>
<td>7.0</td>
<td>27.8</td>
<td>18.6</td>
</tr>
<tr>
<td>6.7</td>
<td>34.0</td>
<td>22.7</td>
</tr>
</tbody>
</table>
Global Manufacturing Close to your Drilling Site

- Guin, AL
- Naju, Korea
- Tilloy, France
- Cottage Grove, MN
- Coming Soon Brazil
Packaging and Transportation

From our Warehouse to your facility

Available in:

- Small box (100 lb)
- Large Box (200-850 lb)
- Bulk Bags (200-1000 lbs)
- Bulk Liner
Storage and Handling

- Minimum storage conditions are unopened cartons in an unheated warehouse.
- Carefully re-tie open bags after use.
- During hot and humid months store in the driest coolest space possible.
- Diaphragm pumps and Pneumatic conveyor systems have been used successfully to transport 3M™ Glass Bubbles from shipping containers to batch mixing equipment.
- Static eliminators should be used to prevent static charges.
- For product Health, Safety and Environmental information, refer to product label and Material Safety Data Sheet (MSDS) before using product.
Compatibility with Standard Equipment

3M™ Glass Bubbles are compatible with:

- Shakers
- Cyclones
- Triplex pumps
- Centrifugal pumps

Suggested Centrifuge setting when using 3M™ Glass Bubbles

- Reduce feed rate to approximately \(\frac{1}{2}\) of the conventional rate to prevent overloading of effluent exit ports.
- Lower the speed of the bowl to approximately 50% of the normal settings to minimize liquid removal from the glass bubble slurry.
- Two centrifuges may be used in parallel to accommodate for this changes without compromising the efficiency of the overall solids control process.
Publications on 3M Glass Bubble use in Drilling Fluids


SPE 75508 (2002) Field application of Glass Bubbles as a Density Reducing Agent in an Oil Base Drilling Fluid for Marginal / Low-Permeability / Low-Pressure Reservoirs.


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