Lightweight Cements

Made with 3M™ Glass Bubbles
Lightweight High Performance Cement 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

Also when:

- Working in offshore or remote inland locations where concerns exist regarding spatial footprint and additional personnel needed to operate the specialized equipment.
# 3M™ Glass Bubbles – Engineered Material

## Density

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

*Per 3M QCM 14.1.8 in glycerol.*

## 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>
</tr>
<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>
3M™ Glass Bubble HGS8000X

The unique strength to density ratio and smaller size enables HGS8000X to remain evenly distributed in transportation and handling and stable in a slurry mixture.

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape</td>
<td>Hollow Spheres</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>

![Graphs showing survival and volume frequency against size and pressure.](image)
Global Manufacturing Close to your Drilling Site

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

3M Energy and Advanced Materials Division
Lightweight High Performance Cement with 3M™ Glass Bubbles

**Simple**
- Reduced complexity of operation

**Effective**
- Improved performance

**Versatile**
- Can be used alone or with other low density alternatives

25 µm
3M™ HGS8000X
Lightweight High Performance Cement with 3M™ Glass Bubbles

Simple – Reduced Complexity of Operation

- Engineered material that offers batch to batch consistency
- Easy to formulate
  - Single-phase incompressible slurries
  - Hydraulic calculations simple
  - Predictable density at depth
- Employs conventional cement equipment
  - Cement dry blends are mixed easily using most common cement batch mixing process.
  - Robust enough to survive boxing (mixing) and pumping process in batch manufacturing.
- No additional personnel or specialized training required over cement jobs with unmodified slurries (15.6 –16.4 ppg).
Lightweight High Performance Cement with 3M™ Glass Bubbles

Effective – Improved Performance

- Achieve very low densities
  - Relief cement loss or lost circulation
  - Can reduce or eliminate ‘staging’ commonly encountered with long columns of cement
- Fast Curing time
  - Good strength at 12 and 24 hours
  - Less waiting on cement (“WOC”)
- Highest strength-to-weight ratio and lowest permeability of conventional lightweight options (water-extended and ceramic pozzolan microspheres)
  - High strength allows their use in relatively deep wells
- Long Life of Well
  - Long term durability improved vs. conventional lightweight cement slurries
  - Low shrinkage and low permeability provide a better sheath around the steel casing and hence a better zonal isolation
Versatile – 3M glass bubbles can be used alone or in concert with other low density alternatives to achieve the best combination of performance and economy.

“To keep the permeability down, a special base slurry was developed that would be stable at 7.5 lb/gal base slurry and still have enough strength to withstand the strength reduction induced by foaming the cement density down to 5.4 lb/gal (0.65 SG).”

– SPE 98124 (2005)
Lightweight High Performance Cement with 3M™ Glass Bubbles

Formulating with HGS8000X

<table>
<thead>
<tr>
<th>Component</th>
<th>Density g/cc</th>
<th>Weight %</th>
<th>Volume %</th>
<th>bwoc %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Portland H</td>
<td>3.14</td>
<td>49.79</td>
<td>19.94</td>
<td></td>
</tr>
<tr>
<td>water</td>
<td>1.00</td>
<td>39.76</td>
<td>50.00</td>
<td>79.86</td>
</tr>
<tr>
<td>HGS8000X</td>
<td>0.42</td>
<td>9.96</td>
<td>29.81</td>
<td>20.00</td>
</tr>
<tr>
<td>bentonite</td>
<td>2.522</td>
<td>0.50</td>
<td>0.25</td>
<td>1.00</td>
</tr>
<tr>
<td>Totals</td>
<td>1.2575</td>
<td>100.00</td>
<td>100.00</td>
<td></td>
</tr>
</tbody>
</table>

Less than 20% bwoc HGS8000X is needed to achieve a 11.0 ppg cement slurry.

Water content 50 % v/v

- density
- water content bwoc
Cenospheres (Coal Combustion Waste By-product)

Formulating with cenospheres

Sample A is a commercially available cenosphere rated as premium for oilfield cementing. Reported properties include:

- **Particle Size Range** 1-100 μm
- **Average Particle size** 65 μm
- **Density** 0.70 – 0.85 g/cc
- **Crush Strength** 3000 psi

About 40% bwoc

Sample A is needed to achieve a 11.0 ppg cement slurry. This is assuming 0.77 SG.

Water content 50 % v/v

![Graph showing slurry density and mix water gal/sack vs. Sample A %bwoc](image)
Cenospheres or 3M™ Glass Bubbles?

PDS and SEM Micrographs of Samples as Received From The Supplier

The variation in the quality of the cenospheres may have a profound effect on key slurry properties.

In contrast, the uniformity (and strength) of the 3M Glass Bubbles (an engineered material) is higher and predictable from lot to lot.
Cenospheres or 3M™ Glass Bubbles?

**Surface Versus Downhole Conditions**

“The crushing of cenospheres during cement placement may have adverse effect on the success of the job by affecting the slurry viscosity, stability and yield.” – SPE 119535

“The increase in downhole density and slurry viscosity can be significant.” – SPE 119535
Cenospheres or 3M™ Glass Bubbles?

Yield and Performance

Pound per pound, the amount of cenospheres needed to achieve a 11.0 ppg slurry at 5000 psi is more than double the amount of HGS8000X.

Much more than 40% bwoc Sample A cenospheres would be needed to achieve a 11.0 ppg cement slurry.

Estimated Density at 5000 psi

0.95 g/cc
Lightweight High Performance Cement with 3M™ HGS8000X

New Class of Microsphere Improves Economics and Allows Circulation Where Previous Designs Suffered Losses: A Case History

Agua Dulce Program, Nueces County
10.5 ppg slurry, low fluid loss, no free water or settling, 1,000 psi compressive strength in 24 hr.

“Even the heaviest HGS grades are lighter than the best grades of FAF (fly ash floaters – cen). This is important because, as the microspheres (glass bubbles) density decreases, less additive will be required to deliver the required density reduction.”

“This new HGS material allowed cement to be circulated as needed for completion plans in an area where multiple attempts at conventional cementing failed. While adding the HGS material to the slurry increased the initial cementing costs, the overall well costs were reduced by eliminating the remedial costs.”

If you carry one Glass Bubble in inventory for lightweight high performance cementing MAKE IT HGS8000X!”
Selected Articles on 3M™ Glass Bubbles Usage in Lightweight Cement Slurries

DOE DE- FC26-00NT40919 Ultra-lightweight Cement


SPE 107285 (2007) A Case Study of Latest Technologies Enables successful Completion of ERD Exploration Project off the coast of Tierra del Fuego.


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