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Application Guidelines

3M Advanced Materials Division

3M™ Glass Bubbles in Drilling Fluids

General Guidelines

Note: The purpose of these guidelines is to provide basic information to product users for use in evaluating, processing, and troubleshooting their use of 3M™ Glass Bubbles. The information provided is general or summary in nature and is offered to assist the user. The information is not intended to replace the user's careful consideration of the unique circumstances and conditions involved in the use and processing of 3M glass bubbles. The user is responsible for determining whether this information is suitable and appropriate for the user's particular use and intended application.

Introduction

3M™ Glass Bubbles HGS Series help achieve and maintain target densities in drilling, completion and workover fluids. These low-density drilling fluids help minimize differential sticking, lost circulation, reduced penetration rates and other problems associated with excessive overbalance conditions. Glass bubble-based fluids can be reconditioned and reused, helping you reduce costs.

- More homogeneous and incompressible fluid properties compared to aerated systems
- More economical and allow a greater density reduction window than synthetic oils
- Compatible with both water-based and oil-based systems

Steps for Preparation and Use of Glass Bubble-Based Lightweight Drilling Fluids

This manual provides general guidelines when using lightweight drilling fluids containing 3M glass bubbles. A total of 14 consecutive steps are presented in four distinct sections, as shown in Figure 1.

A Lightweight Drilling Fluid Preparation

The main objective of the preparation stage is to achieve target density.

1. Prepare base mud following standard procedures.
2. Confirm that the base mud volume and the amount of glass bubbles to be dispensed match the desired formulation.

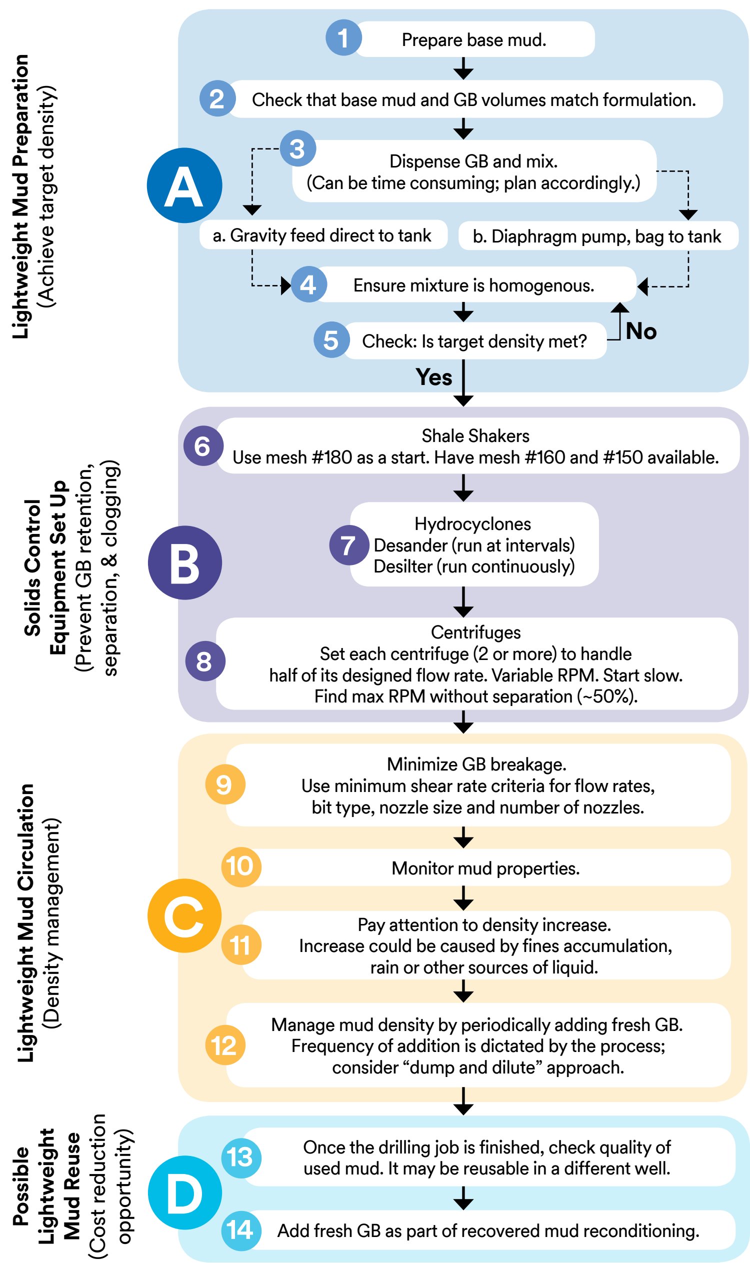

Figure 1. Preparation and use of lightweight drilling fluids containing 3M glass bubbles.

3. Dispense 3M™ Glass Bubbles and mix. Note that dispensing glass bubbles can be time consuming, so plan accordingly.

Conventional solids are generally introduced into a fluid through venturi feed hoppers. Glass bubbles dispensed with this method, however, may be prone to caking and bridging.

An alternative is to incorporate the glass bubbles into the drilling fluid as a stream carried by compressed air or fluid. Dust generation may occur with the use of compressed air; operators should use appropriate personal protection equipment (for additional information, refer to the product Safety Data Sheet). There are two possible approaches to this dispensing method:

a. Use a gravity feed direct to the mud tank. This is the recommended approach, and the following modifications may aid in the process. Adding a fluid stream may help to reduce dust generation. The fluid stream – in this case, the circulating drilling fluid – creates a siphon effect, which reduces airborne dusting. The size of the gravity chute and the volume of fluid should be optimized to the discharge volume. For improved feed, fluidize the glass bubbles by injecting compressed air at low pressure into the bag, just below its bottom opening.

b. Pull the glass bubbles from the bulk bag using a suction wand and dispense them directly into the mud tank using a diaphragm pump. If the tip of the wand does not have a protecting guard, keep the wand away from the bag liner, to prevent clogging the flow. Attention must also be paid to the pump. Frequent cleaning is required to reduce the risk of pump failure due to glass bubble accumulation in the diaphragm. It may take over 10 minutes to empty a bulk bag using this method.

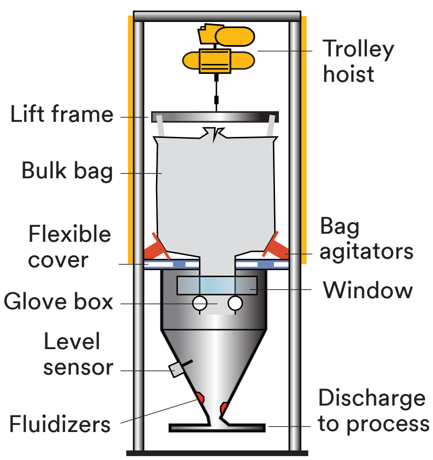

Figure 2. Glass Bubble Transfer via Direct Gravity Feed

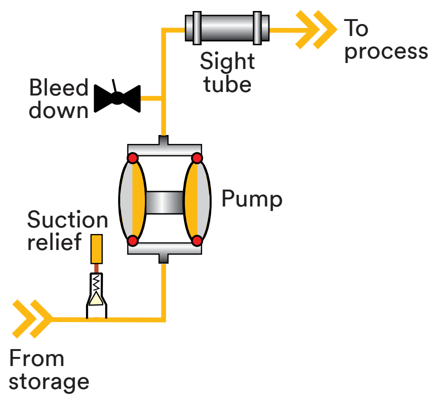

Figure 3. Glass Bubble Transfer via Double Diaphragm Pump

4. Ensure that the mixture is homogeneous. Initially, the glass bubbles tend to float on the surface of the mud. However, as long as the base mud has already yielded (in the presence of viscosifiers), the homogenization process is relatively simple. High shear is not necessary.

5. Confirm that target density and rheological properties have been achieved.

B Solids Control Equipment Set Up

Solids control equipment is used to remove as many drilled solids (cuttings) as possible, while retaining as much liquid (and the glass bubbles in it) as possible. Drilled solids are removed from the drilling fluid with shale shakers, hydrocyclones and centrifuges, among other types of solids control equipment. Equipment must be properly configured to prevent glass bubble retention, separation and clogging.

6. Shale Shakers: Shale shakers are used to remove the largest drilled solids. A shale shaker vibrates a screen to cause rapid separation of the whole drilling fluid from the oversize drilled solids. Particles too large to pass through the screen are separated from the drilling fluid for disposal.

Screening surfaces used in shale shakers are generally made of woven wire screen cloth. Non-layered screens have a single screen cloth mounted in a screen panel. These screens have openings that are regular in size and shape. Mesh size is defined as the number of openings per linear inch in a screen.

To avoid glass bubble retention, we recommend starting with mesh size #180 and having a #160 or #150 mesh on standby.

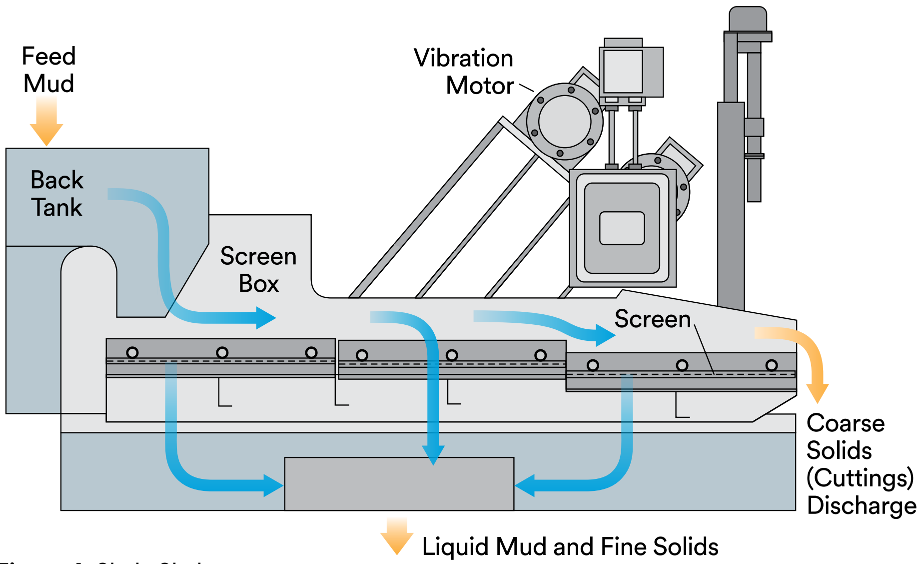

Figure 4. Shale Shaker

7. Hydrocyclones: Hydrocyclones consist of an upper cylindrical section fitted with a tangential feed section and a lower conical section that is open at its lower apex, allowing for drilled solids discharge. Drilling fluid from a centrifugal pump enters the hydrocyclone tangentially at high velocity through a feed nozzle on the side of the top cylinder. As drilling fluid enters the hydrocyclone, centrifugal force on the swirling slurry accelerates the heavier drilled solids toward the cone wall. The drilling fluid rotates rapidly while spiraling downward toward the apex. The drilled solids along the cone wall exit the cone through the apex opening. Liquid, lighter drilled solids and glass bubbles (one order of magnitude lighter than drilled solids) that have been concentrated away from the cone wall are forced to reverse flow direction into an upward spiraling path at the center of the cone to exit though the vortex finder.

   Hydrocyclones are effective in removing finer cuttings down to as low as 20 microns in diameter, without stripping out the glass bubbles. Note that there are two different sizes: desilters (2–6 inch), which should be run continuously when using glass bubbles, and desanders (6–12 inch), which should be run at intervals when using glass bubbles.

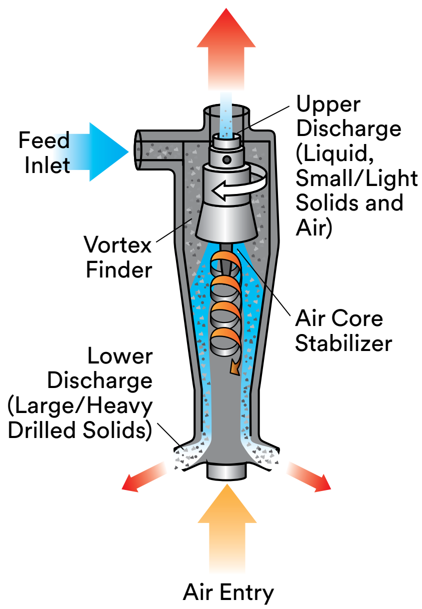

Figure 5. Hydrocyclone

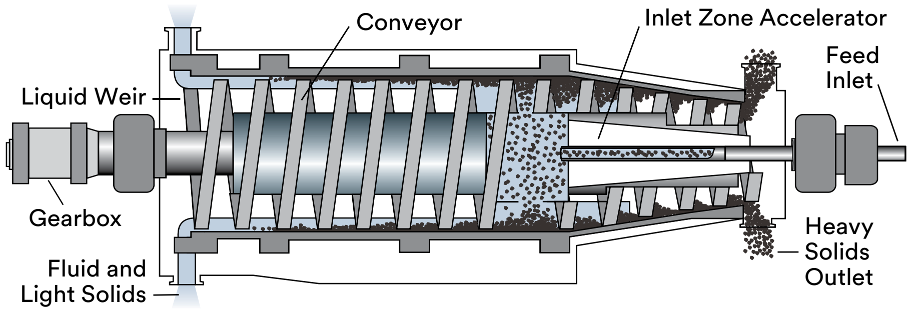

Figure 6. Centrifuge

8. Centrifuges: A centrifuge consists of a rotating conical drum. Drilling fluid is fed into one end and the separated solids are moved up the bowl by a rotating scroll to exit at the other end. Centrifuges can remove finer solids than can hydrocyclones or shaker screens.

   To prevent clogging and glass bubble separation, set each centrifuge to handle half of its designed flow rate. More centrifuges may be needed to handle the total flow rate. Also start at low RPM and increase slowly to find the maximum possible speed without separation (usually about 50% of the maximum RPM).

C Lightweight Drilling Fluid Circulation

Density should be continually managed for optimal performance. Lowering the drilling fluid density to a certain value may not prevent fluid loss completely, especially if there is a gap between expected and actual conditions (formation characteristics). Dramatic fluid loss and lost circulation should be addressed according to general practices in drilling.

9. Use minimum shear rate criteria when designing flow rates, bit type, nozzle size and number of nozzles to prevent excessive glass bubble breakage.
10. Monitor drilling fluid properties as usual. 3M™ Glass Bubbles are solid particles, and as such their presence may reduce the solids (fine cuttings) load at which the fluid viscosity becomes unmanageable. Consider the "dump and dilute" approach as a viscosity management measure. This approach consists of discarding a fraction of the used drilling fluid and replacing it with freshly prepared drilling fluid.
11. Pay attention to density increase. Drilling fluid density increase may result from glass bubble breakage or several other factors (i.e. fines accumulation, rain or other sources of liquid). In case of density increase, apply appropriate corrective measures based on the source of the increase.
12. Manage drilling fluid density by periodically adding fresh glass bubbles. The frequency of fresh glass bubble addition will be dictated by the process. Refer to the case study on the following page for an example.

    Consider the "dump and dilute approach" as a density management measure that can be used in combination with periodic glass bubble addition. Make sure that the new mixture's density matches the target density.

D Possible Lightweight Drilling Fluid Reuse

Help reduce costs by reconditioning and reusing drilling muds.

13. Once the drilling job is finished, check the quality of the used drilling fluid. It may be possible to reuse the fluid in another well.
14. Add fresh glass bubbles as part of recovered mud reconditioning.

Case Histories

OMAE2017-62131 *Lightweight Hollow Glass Microspheres Drilling Fluid Flow through Nozzles*

SPE-183681 (2017) *An Overview of Experimental Studies Examining the Reliability of Hollow Glass Spheres as Density Reduction Agent in Oil Field Applications*

SPE-182878 (2016) *Drill-in Fluids Design and Selection for a Low-Permeability, Sub-Hydrostatic Carbonate Reservoir Development*

SPE-180619 (2016) *Density and Viscosity Predictions of Super Lightweight Completion fluid SLWCF at Reservoir Conditions*

SPE-175737 (2015) *Investigation on the Stability of Hollow Glass Spheres in Drilling Fluids in diverse pH environments and Assessment of Potential Field application in Saudi Arabia*

SPE-174010 (2015) *Hollow-Glass Sphere Application in Drilling Fluids: Case Study*

OTC-26162 (2015) *Alternative Technologies in Drill-In Fluids for Depleted Reservoirs*

OTC-25044 (2014) *Hollow Glass Micropspheres: An Option for Dual Gradient Drilling and Deep Ocean Mining Lift*

SPE-171465 (2014) *Combination of Subhydrostatic Drilling and UBD to Extend the Life of Mumbai High Giant Oil Field*

SPE-167619 (2013) *Rheological Properties of Drilling Fluids Mixed with Lightweight Solid Additives*

Case History (2012) *Netherlands: Hollow-Glass Spheres Allow Drilling Fluid Densities as Low as 0.8 SG*
http://www.halliburton.com/public/bar/contents/Case_Histories/web/H010280.pdf

SPE-132251 (2010) *Lightweight Water-Based Mud Using Glass Bubbles for Drilling a 6-in Horizontal Section in Gunung Kembang Development Well*

SPE-130326 (2010) *Assessment on the performance of hollow glass microspheres in low density fluids for workover program in fractured basement reservoir at the White Tiger Oil fields, Cuu Long Basin, Vietnam*

SPE-125702 (2009) *Case Study Using Hollow Glass Microspheres to Reduce the Density of Drilling Fluids in the Mumbai high, India and Subsequent Field Trial at GTI Catoosa Test Facility*

SPE-108423 (2007) *Increasing Production Maximizing Underbalance during Perforation*

SPE-82276 (2003) *Improving Performance of Low Density Drill in Fluids with Hollow Glass Spheres*

SPE-62899 (2000) *Field Application of Glass Bubbles as Density-Reducing Agent*

SPE-47802 (1998) *Underbalance Drilling Technique Improves Drilling Performance – A Field Case History*

SPE-38637 (1997) *Field Application of Lightweight Hollow Glass Sphere Drilling Fluid*

SPE-30500 (1995) *Use of Hollow Glass Spheres for Underbalanced Drilling Fluids*

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