Darren Hall, 3M Oil & Gas UK, shows how advances in glass microsphere technology are increasing the efficiency of lightweight drilling fluids for modern drilling operations.

Fluid loss, circulation loss and formation damage are problems all too familiar to drilling operators working on depleted reservoirs, or on rock formations that are geologically frail, poorly consolidated or highly permeable. There can be serious financial consequences attached to each of these scenarios, and drilling operators continue to demand ever-more efficient and cost-effective solutions to resolve them.
The cause of these problems often involves the inability of a conventional drilling fluid to overcome the excessive pressure differential between the borehole itself and the surrounding hydrocarbon reservoir. Maintaining control over this pressure differential is essential if the operator is to be able to manage the stability of the bore effectively.

Creating near balance or under-balance conditions at the bottom of the borehole will ensure that the hydrostatic pressure inside the well casing is similar to, or slightly lower, than the pressure in the surrounding rock formation. Maintaining this pressure differential allows the operator to effectively seal permeable rock formations, minimise reservoir damage and ensure that the hydrocarbons can flow efficiently into the borehole, ready for extraction up to the surface.

A lightweight approach

Many drilling operators now use special lightweight fluids to help them achieve the differential pressure conditions they require. In a normally-pressured zone where permeability is extremely low, this type of fluid offers the potential to achieve and maintain the correct balance condition, and so maximise the efficiency of the operation.

A typical lightweight fluid must have a very particular set of characteristics, including a low density, excellent dynamic stability and a reasonable degree of viscosity. This allows it to create a low head differential - i.e. a near-balanced drilling condition.

There are, of course, different ways to create drilling fluids with these sorts of characteristics. They can, for example, be aerated, and a fluid, which contains entrained air or gas can provide good performance. However, this solution can also introduce additional complications. For example, a compressible multiphase (gas-liquid) system needs to be managed, and this requires a compressor at the wellhead to maintain the correct percentage mixture of air and liquid. Furthermore, the compressibility of an aerated fluid results in differential pressures between the topside and the downhole. This can add complexity to the calculations, which are required to achieve the desired fluid density and wellbore conditions.

A modern solution

Fortunately, there is another solution, which is continuing to grow in popularity among drilling operators around the world, as it has proven itself to be both an effective and cost-efficient alternative. This involves using a lightweight drilling fluid that is a combination of either a water-based or synthetic oil-based liquid, and microscopic glass spheres such as Glass Bubbles from 3M.

These engineered unicellular glass spheres are the key to the success of this type of drilling fluid. Made from soda-lime borosilicate glass they reduce both the density and the weight of the fluid, and when combined with a stabilising agent they also help to increase the stability of the liquid and give it a relatively low viscous nature. Adding this type of glass sphere to the fluid makes it far easier to maintain a stable balance between the hydrostatic and formation pressures at the bottom of the borehole.

A proven solution

These glass bubbles have been proven in numerous demanding industrial sectors – most notably aerospace and the manufacture of automotive materials. They are common in other oil and gas industry applications – having long been used in the production of buoyancy modules for subsea risers – and they are a key element in the syntactic foam insulation used for deep-sea flow lines. They are also a frequent component of the reduced-density cements used in both downhole, and more general, lightweight cementing applications.

Offering a typical density of 0.42 g/cc and an average particle size of only 25 μm, 3M Glass Bubbles have a uniform, spherical shape and a low surface area. This gives them a unique strength-to-weight ratio that is substantially greater than other material that might be added to drilling fluids. This allows the operator to create a much higher ‘solids’ loading in the base fluid.
system, but with minimal rheological impact when compared to other possible solid-state fluid additives.

Being almost completely chemically inert, incompressible, virtually insoluble in water or oil, and unaffected by the typical temperatures and pressures found in even the most hostile downhole environments, this type of glass bubble is well suited for drilling applications. They can be added to many different types of drilling, completion and workover fluids, where density values as low as 5.4 ppg can be achieved. Because of this, they extend the density window of a single phase liquid into the sort of range normally only available from a traditional aerated liquid. However they eliminate the need for additional compressor equipment on the rig – something, which is particularly beneficial on offshore or remote-location inland rigs where available space is often limited.

Despite being made from glass, the bubbles are extremely strong and rugged. They can withstand the demanding conditions of modern drilling environments and, because of their small size, they allow the operator to use standard mud-handling equipment without fear of causing them any damage and limiting their effectiveness. The bubbles permit at balance, near balance or underbalanced conditions to be created as required, and they can be used to successfully reduce the density of drilling fluids, both water-based and oil-based muds, down to less than 6.0 ppg.

As well as reducing or eliminating fluid loss, circulation loss and formation damage, the glass bubbles offer other benefits to the drilling operator. They can help boost productivity by increasing the rate of penetration, eliminate the problem of differential sticking, promote tight mud cake formation and reduce casing wear. They can even be recycled and reused in neighbouring wells, thus creating even greater cost savings and improving efficiency. It is important to realise too, that the use of this particular lightweight fluid technology is not necessarily limited to depleted reservoirs, and they can be used on new drilling locations with similar results.

A case in point
The benefits of this innovative solution are highlighted by the case of an onshore rig in the Netherlands. The rig operator was looking to develop a low pressure gas reservoir which was located in a sandstone formation, and which had been depleted by previous production operations. The fracture gradient was located low in the virgin reservoir, and the depletion level was thought to be quite significant. The problems of lost circulation and formation damage were seen as significant hazards, which might be encountered by any future drilling, and so a low density drilling fluid was needed to create the balanced pressure conditions that would enable drilling to recommence.

The operator was recommended a low density invert emulsion formulation as being suitable for this particular rock formation. The fluid featured a high oil-to-water ratio, plus a low solids content, which minimised its density. This was enhanced by the inclusion of 3M Glass Bubbles in concentrations of up to 25%, which allowed the required density of 0.8 sg (8.33 ppg) to be achieved.

Laboratory tests showed that the fluid was stable, and demonstrated predictable behavioural properties that would help minimise any damage to the rock formation. Once applied to the well's reservoir section, the fluid was carefully conditioned throughout the drilling process. A centrifuge was used to separate the drilling solids from the drilling liquid, and this process was assisted by the natural buoyancy of the glass bubbles. All operational parameters, including the density of the liquid, were monitored and maintained throughout the process, and this revealed that the drilling fluid performed well, and the glass bubbles proved themselves to be very resilient, with over 90% of them remaining intact.

The use of this customised solution helped the reservoir section to be drilled successfully in just one bit run, with the density of the drilling fluid being maintained at 0.8 sg, and any formation damage being prevented.