Cesium formate fluid succeeds in North Sea HPHT field trials

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CABOT SPECIALTY FLUIDS (CSF) has confirmed the first successful major field trials of its new cesium formate fluid in the UK sector of the North Sea. These were the first applications worldwide of this recently developed fluid. The company believes that this new technology has lived up to expectations and has delivered excellent results in completion operations for three major oil companies.

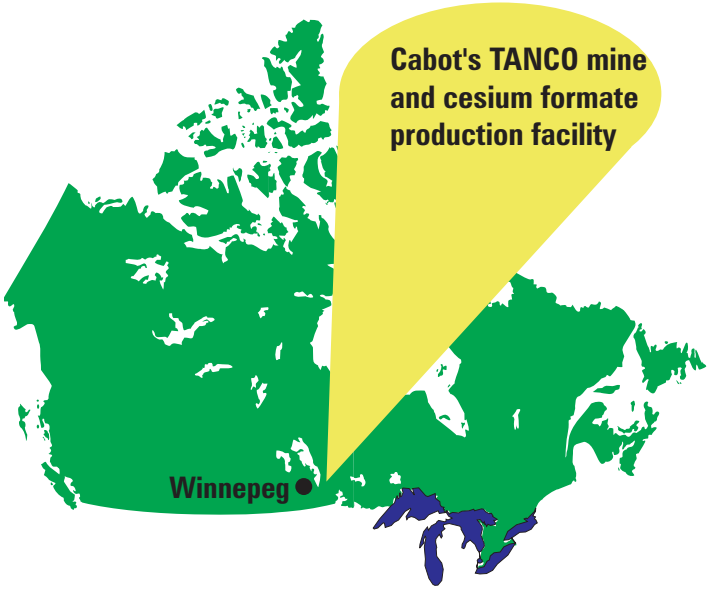
Cesium formate fluids are derived from pollucite, a mineral rich in cesium, which is found in abundance at Cabot's TANCO mine in Manitoba, Canada. Construction of the production facility adjacent to the mine was completed in 1997, capable of producing 12,000 bbl of cesium formate annually. cesium formate is now available in quantity in the North Sea and the Gulf of Mexico.

Cabot Specialty Fluids' Cesium fluids are targeted to replace materials historically used in the petroleum industry, but which are increasingly coming to be considered unacceptable on health, safety and environmental grounds. By contrast formate based fluids are environmentally acceptable, have low corrosion rates, are biodegradable, and provide the industry with a safer alternative to current technology along with an expanded performance range.

The primary use of cesium formate fluids in oil and gas wells is to control well pressures while drilling or completing wells.

Cesium formate is the heaviest of the monovalent alkali metal salts, all of which are very soluble in water and form high density fluids with a range of beneficial properties. This makes them ideally suited for use as drilling and completion fluids. The three monovalent formate salts considered most useful and commercially available to the oil industry are Sodium formate, Potassium formate and now cesium formate.

Cesium formate has a maximum density of 2.3 specific gravity (sg) and may be blended with the other formates, Sodium and Potassium to give a fluid of any density between 1.0 sg and 2.3 sg depending on the density required for a specific application. At the lower end of the density scale Sodium formate and Potassium formate are blended for the range of 1.0 sg to 1.6 sg and the higher range of 1.6 sg to 2.3 sg are obtained by blending potassium formate with cesium formate, as shown in Figure 1.



Cesium is produced from the mineral pollucite, found in abundance at Cabot's TANCO mine in Manitoba, Canada. A production facility adjacent to the mine was completed in 1997 and can produce 12,000 bbl of cesium formate annually.

Formate fluids can be viscosified with conventional biopolymers for use as a drilling fluid, which are stable to 160°C. Drilling fluids made up of formate-based fluids need no solid weighting agents such as barite, as the density is an inherent property of the fluid itself. Typically CaCO3 is added at 1.0-3.0% for pore bridging along with polymeric fluid loss materials, whereas a typical drilling fluid will contain up to 40% by volume of solids to obtain an equivalent density. The particle-size distribution of the CaCO3 is optimised using the D½ or logD rules for permeability reduction of the pore-size distribution found in the formation.

In the early 1950s, divalent calcium formate and acetate drilling fluids were initially developed and applied in the field. Little is known about how these early applications of formate based fluids behaved and it was not until the development of the monovalent formate based fluids in the early 1990s with the application of monovalent acetate and formates that the technology evolved. All the developmental work and early field trial successes with formate-based fluids have taken place in the European sector of the world, both offshore and onshore. However, formate-based fluids, including acetates, have been and are presently being applied in other parts of the world including: Western Canada, Texas, and Gulf of Mexico in North America; and Argentina, Ecuador and Venezuela in South America. A rough count of formate based fluid operations around the world is now 90+. As preliminary as the reports are from these drilling and completion/workover operations, it is already appreciated that the advantages of formate-based fluids are being realized. Of all the benefits of formate-based fluids the most important are their solids free and environmentally benign nature and the resultant increases in productivity and cost effectiveness that is being recognized as this new fluid technology gains momentum.

Cabot Specialty Fluids have also developed a polymer, which is soluble in formate-based fluids and is thermally stable to 218°C. This polymer, 4mate-vis-HT, has been designed specifically for use in HTHP wells. In 2 of the 3 North Sea field trials discussed here the polymer, 4mate-vis-HT, has been successfully used.

Extensive laboratory testing has been conducted on cesium formate to verify that the downhole conditions to be

encountered would be satisfied by its expected performance. Its physical and chemical properties, which were unknown, have been measured. Also the compatibility of cesium formate with the reservoir formation and metals and elastomers which make up the downhole tubulars and tools have been tested under the field conditions in which it was expected to perform. It is well appreciated that laboratory testing is much more aggressive on materials properties than one finds from field application. That has certainly proved to be the case for cesium formate in its first three field trials, exceeding expectations in ways only available from direct field application.

The ability to reclaim and recycle cesium formate has been strategically necessary as part of the development program due to the inherent high price of extracting cesium and its limited long term availability. Reclamation of formates begins at the rigsite where the fluids are separated by type into separate containers. In general conventional filtration equipment can be used to reclaim formate based fluids, supplemented by chemical treatment. If polymers are added the viscosity of the fluids must be reduced for efficient solids removal. The polymer stability and the small amount of free water in formates significantly influences standard procedures for brine recycling. Since typical polymer breakers (hypochlorites, acids, etc) do not work efficiently in formate environments, specialized chemical treatment is required in combination with mechanical separation using centrifuges and/or high-pressure DE filter press. The use of shakers fitted with fine screens (250, 325 and 400 mesh) has also proved to be very successful for solids separation. The application of novel separation technologies (including ultrafiltration and evaporation for redensification) can also be applied to recover the fluids, but only if economics allow. This is normally only the case for potassium and cesium formates. To further improve economics, formate-based fluids are normally used on a rental base. Rental not only reduces the cost per unit, but also eliminates the need for disposal.

The first uses of cesium formate brine took place in the UK sector of the North Sea during the last quarter of 1999.

Shell (UK) Expro used Cabot's cesium formate in a coiled tubing completion operation on the HTHP Shearwater development to minimize the risks associated with very high reservoir temperature and pressure (182°C [365°F] and 965 bar [14,000 psi]). Given that Cabot's cesium formate fluid was awarded the highest environmental rating by the **UK Department of Trade and Industry**, its use fits well with Shell's efforts to utilize "best practice" technologies.

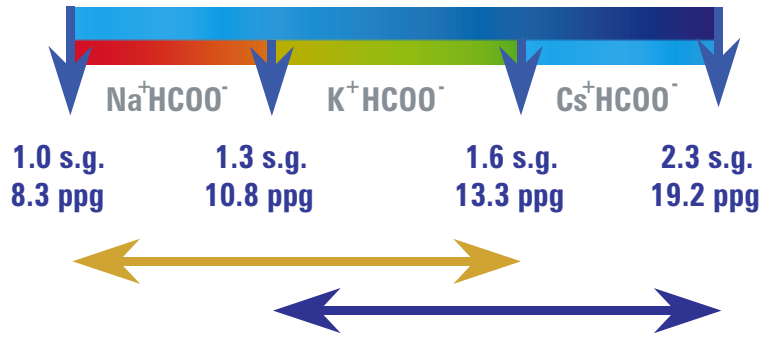


Figure 1: High density cesium formate can be blended with sodium and/or potassium forfmate to created a fluid of any density between 1.0 sg and 2.3 sg.

The second application of cesium formate was as a completion fluid on an extended-reach departure well D22, on **TotaFina's** Dunbar platform in the Northern North Sea. Totalfina engineers turned to cesium formate after initial attempts to complete the well met with sustained and costly difficulties. The well was initially drilled to a measured depth of 7,353 m (24,124 ft), with a true vertical depth of 3,492 m (11,457 ft), and a horizontal displacement of 5,655 m (18,553 ft). In terms of length and horizontal displacement, the well is a record for **Total Oil Marine plc**. Cesium formate was selected for this completion because it provided the required density and a solids-free environment; was safe for crews to handle and non-damaging to the environment; proved compatible with all major elements of the completion equipment, and, featured a low co-efficient of friction. Cesium formate's low co-efficient of friction and beneficial lubricity, successfully promoted the running of the completion and coiled tubing strings into this long, highly deviated well; a task that previously attempted but failed with conventional oil based fluids and water based completion fluids.

The third use of cesium formate was also its first use in a live HTHP well. This was on **Elf Exploration's** Elgin/Franklin field in the Central Graben area of the Central North Sea, a development that is widely considered to be the most challenging high pressure, high temperature development yet undertaken in the North Sea.

The well utilized 2.19 sg cesium formate in an Ultra High Pressure, High Temperature completion operation where reservoir pressure is 1,105 bar (16,000 psi) and bottom hole temperatures reached 205°C (401°F). The well had a measured depth (MD) of 6,446 m (21,143 feet), a true vertical depth (TVD) of 5,503 m (18,050 feet), with a maximum deviation of 450 ft.

Elf Exploration's well engineers utilized cesium formate in this phase of the project because of the fluid's solids-free nature; temperature stability, handling safety for crews and environmental acceptability. The fluid was also proved to be compatible with all major elements of completion equipment (metals and elastomers), under extreme conditions of temperature and pressure.

The success of the first major applications of any new technology is critical in the introduction process. These successful applications of cesium formate demonstrate that this fluid has tremendous promise as an alternative to current drilling and completion fluids technology in the oil and gas drilling industry.

ABOUT THE AUTHORS

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