FORMATE MATTERS

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Boosting UK gas production

One of the most important parameters to judge success of a completion is the recovery rate of hydrocarbon reserves over time. Thirteen years after cesium formate was first used, Formate Matters looks back over the completion operations using cesium formate in the UK sector of the North Sea.

PHOTO: © GEORGE STEINMETZ/CORBIS

UK wells completed in cesium formate brine show superior production rates

From September 1999 until now, cesium formate brine has been used in 15 wells spread over eleven HPHT gas fields in the UK sector. Cesium formate brine was first used as a perforation fluid in an underbalanced HPHT workover in Shell's Shearwater field. This was followed by the post-perforation completion of two of Total's Elgin/Franklin wells (G-1 and G-3) in November 1999. Elgin/Franklin is the world's largest HPHT field and has challenging reservoir conditions, including pressures to 1,100 bar (15,954 psi) and temperatures to 190°C (374°F).

Since then a further 12 HPHT well completions with cesium formate brine have been carried out in Devenick, Braemar, Rhum, Judy, Glenelg, Kessog, Jura and West Franklin. Of these, Kessog and Devenick are appraisal wells and all have been completed by perforating in cased hole after drilling-in with oil-based muds, with the exception of Devenick.

Under control

Five HPHT gas fields in the UK sector have used cesium formate brines exclusively to provide well control during perforating operations in the development phase. Perforating has been conducted in a variety of modes – overbalance, conventional underbalance and dynamic underbalance. Some details of the five fields and the well conditions during perforating are shown in the table. Braemar and Glenelg are rich gas condensate fields (> 100 bbl condensate per million scf of gas), each drained by single wells. Jura and Rhum are lean gas condensate fields, drained by two and three wells respectively. Glenelg and West Franklin are the deepest, hottest and highest-pressure fields in the UK North Sea. The reservoirs are all sandstone.

Jura in the crown

Data available from the website of the UK Department of Energy and Climate Change suggest that gas production rates from nine HPHT development wells perforated in cesium formate brine have been between 1.6 and 2.6 million m^3 per day during plateau phase, with the Jura wells being the most productive.

30,000 boe and counting

Production figures from West Franklin are not published on the DECC website, but it was reported in 2008 that the West Franklin well F9 was delivering 2.6 million m^3 of gas per day after perforating in cesium formate brine. TOTAL states on its website that: "...F9 can produce more than 30,000 barrels of oil equivalent (boe) per day, making it one of the most productive wells in the North Sea." The Glenelg well falls into the same category, with a 30,000 boe/day capability, helped by healthy condensate production of 500,000 m^3 per year in plateau phase.

The single Braemar well has now delivered nearly 100% of the field's recoverable gas reserves (3.28 billion m^3) in just over eight years full production. Cumulative gas production from the Rhum wells reached almost 8.0 billion m^3 by November 2010.

No cumulative production figures are available for the Judy P-20 well, but early production was 0.93 million m^3 of gas per day, together with 13,000 bbl per day of condensate on a 31% choke (production choked back for reservoir management reasons).

Production first

Results show that all HPHT gas wells perforated in cesium formate brine have delivered between 1.6 and 2.6 million m^3 per day of gas during plateau phase, including two with 30,000 boe/day production capability. In fact, the Braemar well has already delivered nearly 100% of recoverable reserves in a little over eight years of full production. So, if it's accepted that production is the key indicator of a successful completion brine, then cesium formate would appear to be a clear contender for operators faced with HPHT gas condensate reservoirs.

HPHT gas development wells completed exclusively with cesium formate brine as perforating fluid

Field	Operator	No. of wells	Depth		Pressure (bars)	Temperature		Well head	Brine density (kg/m^3)
			metres	feet		°C	°F		
Braemar	Marathon	1	4,500	14,764	701	136	277	Sub-sea	1.86
Rhum	BP	3	4,750	15,584	862	149	300	Sub-sea	2.19
West Franklin	TOTAL	2	7,327	24,039	1,154	204	399	Platform	1.94
Glenelg	TOTAL	1	7,385	24,229	1,150	200	392	Platform	1.78
Jura	TOTAL	2	3,935	12,910	702	127	261	Sub-sea	2.09

CABOT creating what matters Specialty Fluids

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PEOPLE

Ann-Christin, Operations Engineer, Norway

Ann-Christin joins the team

Ann-Christin Nielsen, 43, joins Cabot Specialty Fluids in Norway from M-I Swaco as Operations Engineer. She worked in M-I for 15 years in several roles, including Drilling Fluids Engineer, Laboratory Engineer and Senior Sales Engineer. Ann-Christin says: "The new position is very varied and offers me the opportunity to work with cesium formate brine and challenging HPHT wells, which I enjoy."

Ann-Christin is married with two children aged 9 and 12. She has a BSc in Environment and Aquaculture Technology from Bergen University College and enjoys travel, cross-country skiing and horse riding.

Stuart Leon is based in Aberdeen

New promotion

From high-street Retail Manager through Plant Operator and Laboratory Technician to Technical Service Engineer, Stuart Leon, 33, has worked his share of jobs. Seven years with Cabot Specialty Fluids has given him the experience and training needed to bring him this promotion. Stuart says: "As Technical Service Engineer, I enjoy exploring all aspects of our business and can provide a bridge between our lab/R&D and our operations/engineering teams. I also like to visit customers and explain why I am so enthusiastic about formates and why they should be too."

Stuart is married to Ingrid, has a 20-month-old daughter and is a singer, songwriter and guitarist for the rock band 'eric euan'. Claims to fame: supporting the Stranglers and becoming a favourite of the late DJ John Peel. Tracks available on iTunes.

Changing the curriculum

Teacher, Roustabout, Derrickman, Fluid Engineer – Jim Turner, newly retired General Manager of Cabot Specialty Fluids, has much to look back on.

In his early career, Jim chose a very different path than oil and gas. He trained as a teacher in Edinburgh before joining a UK aid scheme and moving to Nigeria. From his original position as School Inspector, he switched to teacher training before returning to his native Scotland in the late 1970s.

"The oil industry was booming," says Jim. "And it was easy to get a well-paid job offshore. With a young family to support it was a good stopgap solution before I found something more suitable. The only problem was I enjoyed the lifestyle and never looked back."

Jim worked his way up the ladder starting at Deutag as Roustabout and Derrickman before moving to International Drilling Fluids as Fluids Engineer and ultimately UK Operations Manager. Right before moving to Cabot, he was BP Account Manager at Baroid.

At the end of 1996, Jim was asked to join Cabot Specialty Fluids as European Regional Director. "Cabot needed a 'good North Sea hand' to get the cesium formate business going," says Jim. "It certainly was an interesting proposition – to introduce novel, premium-priced brine which, due to its scarcity, was reclaimed after use. The first year was spent setting up the Aberdeen operation and presenting cesium formate to operators.

The initial months were tense waiting for an operator to take a 'leap of faith' and try cesium formate for the first time. "The breaks came in 1999. First, Shell Expro ran a field trial on Shearwater and then TOTAL gave us our first big job," continues Jim. "TOTAL had been trying to control gas influxes while completing a well in its Dunbar field. Heavy brine was needed that met the safety and environmental regulations. Zinc bromide was clearly out so, after a cost-benefit analysis, cesium formate brine was used successfully to complete the wells."

When asked what highlights he remembers, Jim names the first drilling job in Norway on Huldra, BP Devenick in 2001 and cesium formate's position as the favoured HPHT fluid for completion and drill-in operations for Statoil and TOTAL. Furthermore, expansion into other regions, particularly the Far East and Kazakhstan, are achievements Jim will remember.

Jim Turner fishing the Dee close to Aberdeen

So what's next? Jim plans to spend time with his family and travel more. He's just back from Jordan and is visiting New Zealand and the South Sea islands later this year. "And then there's fishing," Jim says. "There's nothing like a day out on the Dee and the chance of fresh salmon." Sounds like a very enjoyable retirement indeed!

DID YOU KNOW?

Finding cesium

Bunsen burners are an essential in science labs as any school child with singed eyebrows will tell you, but what has this specifically to do with cesium? The answer is its inventor, Robert Bunsen (1811–1899) who, together with his partner Gustav Kirchoff, discovered cesium.

In 1860, Bunsen and Kirchoff took full advantage of newly developed spectroscopy to analyse mineral water from Bad Durkheim in southwest Germany. When the water sample was heated it produced a series of characteristic spectral lines. Sodium, potassium, lithium, calcium and strontium were all identified. Nothing notable here – they were already known to science. However, the spectroscope showed something new – two clear blue lines remained in the 'empty' mineral water. A new mineral had been discovered, the first using this new technique. Bunsen called it cesium, from the Latin word caesius, meaning light blue. Hence it's spelling of 'caesium' in British English.

IMAGE: GRANGER COLLECTION

Gustav Kirchoff and Robert Bunsen using an early spectroscope

Cesium is soft, white alkaline metal with an atomic weight of 132.9 and is the most electropositive of all elements. There are several isotopes of cesium, but naturally occurring cesium 133 is found in pollucite or lepidolite. Although cesium is found in the US, Zimbabwe and southwest Africa, the dominant source is at Lake Bernic, Manitoba, Canada, in mines owned by Cabot Corporation. The largest commercial application is in the creation of formate brine, although cesium 133 is also used in electron tubes, glass and ceramics production, specialist optical instruments and the Atomic clock.

Kept in suspense

Statoil's Kvitebjørn field takes its name from the Norwegian folk tale the 'White Bear King Valemon'. Full of suspense, the story has entertained children through the ages with recounts of a cursed king turned into a white bear and a princess who helps him gain his freedom.

Kvitebjørn A7 may not have been kept in suspense so long as our good king – it was a seven-year curse – but a 448-day HPHT suspension in a well with a BHST of 135°C (275°F) still makes a nice story.

Record cesium formate drilling-fluid suspension

At 448 days, Kvitebjørn A7 is the longest suspension in cesium formate drilling fluid ever completed. After drilling-in and completing in cesium formate, non-fluid-related issues compromised well integrity and led Statoil to plug back the reservoir section and suspend the well.

Universal fluid pays dividends

Rather than reformulating a new brine solution, cesium formate's unique properties and stability enabled Statoil to reuse the drill-in fluid already in place on the platform for the suspension. The only addition was a small amount of cesium formate spike fluid to increase fluid density to 1.99 g/cm^3 (16.61 lb/gal) and base-brine density to 1.96 g/cm^3 (16.36 lb/gal). This provided the required hydrostatic pressure. Otherwise the composition remained the same – cesium/potassium formate as base brine with potassium carbonate/bicarbonate pH buffer, xanthan, ultra-low viscosity PAC, modified starch and a small amount of calcium carbonate. The fluid contained no biocide or corrosion inhibitor.

A 15-month wait

"It's always exciting to see the fluid after a long-term HPHT suspension and A7 was no different – even though we had good experience with cesium formate drilling fluid in a shorter Kvitebjørn well suspension," says Knut Ove Haarstad, Drilling Supervisor in Statoil. In December 2011, after 448 days, the cesium formate fluid was circulated out of the hole. The operation went smoothly and 18 samples were obtained from depths of 750 to 4,900 metres (2,461 to 16,076 ft). Knut Ove Haarstad at Statoil comments: "The fluid was in excellent shape, which was impressive after 15 months static under HPHT conditions."

As cesium formate is naturally high density there are no weighting solids to sag. In line with expectation, analysis of the 18 samples showed slight density differences between top and bottom fluids caused by a small amount of low-gravity solids added to the drilling fluid. At no time, however, did density fall below the original base brine weight of 1.96 g/cm^3 and compromise the fluid barrier.

Extensive testing showed that the fluid did not suffer microbial degradation or significant thermal decomposition. pH stayed relatively stable throughout the suspension, indicating that high levels of buffering capacity remained in the fluid. API fluid-loss properties were still superb over the full height of the well, which suggests that ultra-low viscosity PAC functionality did not suffer from severe temperature conditions at well bottom.

PHOTO: NTB SCANPIX

The plot thickens – princess riding the white bear 'Kvitebjørn'

Moving on

The suspension gave Statoil time to workover an adjacent well and re-plan further activity on A7. This consists of cement plugging the lower sections of A7 and drilling a technical sidetrack to ensure that well integrity and production are maximised.

TECHNICAL FORUM

Manual labour

Section B10 Compatibility with the Reservoir is now downloadable from formatebrines.com/manual. This new section focuses on the known causes of formation damage and explains why formate brines are unlikely to cause it. Furthermore, it looks at formation damage testing, common laboratory pitfalls, performance of scale prediction packages and the results delivered by formate brines and other oilfield fluids.

Updates are also available for sections A2 Brine Density and PVT Data, A3 Water Activity and Colligative Properties and C2 Fluid Testing and Property Maintenance from the same link.

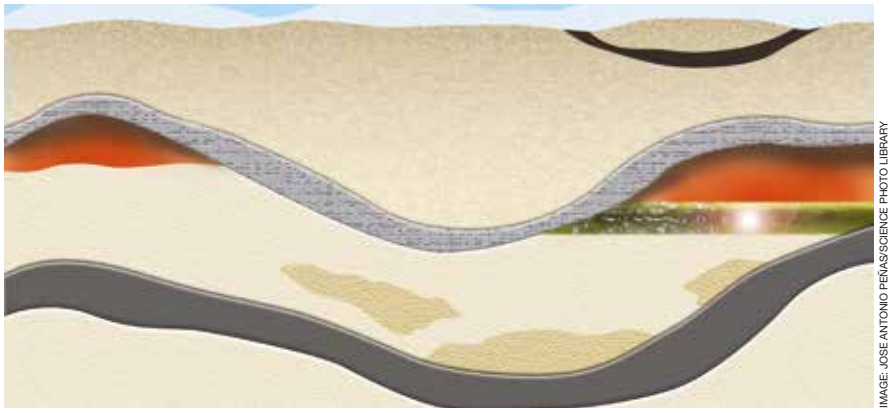

IMAGE: JOSE ANTONIO PEÑAS/SCIENCE PHOTO LIBRARY

New section B10 studies formate brines' reservoir compatibility

TECHNICAL FORUM

TCT measurement breakthrough

A simple and reliable new method to measure TCT (true crystallisation temperature) of formate brines is the result of a three-year TCT behaviourial study by Cabot Specialty Fluids.

Sodium, potassium and cesium formate are exceptionally soluble in water and form brines with very high density and low water activity. The low water activity gives these brines unique properties that are beneficial in forming base fluid for drilling and completion fluids. One such property is low crystallisation temperature, which helps increase the fluids' performance limits. True crystallisation temperature in diluted cesium formate brine reaches as low as -60°C (-76°F).

Ever since formate brines were introduced in the oilfield in the 90s, test laboratories have struggled with achieving good TCT measurements. The standard API measuring method simply does not work in formate brines and it is quite common to see TCT values reported as 'too low to measure', even in cases when TCT is well within the measureable limit of other fluids. Factors that complicate TCT measurements in formate brines are: a) TCT values are often very low, and often lower than the cooling bath's temperature settings, b) an enormous amount of supercooling occurs and c) metastable-phase potassium formate crystals form in potassium containing formate brines.

The goals of the three-year research programme were to understand the unusual TCT behaviour of potassium formate and to develop a reliable method to measure TCT of all formate brines. Both have been clearly achieved. The key to successful TCT measurements is found in seeding. Intelligent seeding eliminates all problems from metastable-phase crystals and supercooling. The new method is simple, reliable and uses no specialised equipment. For further information, please download Formate Technical Manual section A5 from formatebrines.com/manual or send a mail to formate.manual@cabotcorp.com.

Cabot Specialty Fluids has developed a unique method for successfully measuring TCTs in formate brines

Mineral wealth

Geology is an important science for our industry, but how good is your knowledge of the minerals our planet holds? Is it rock solid or will it turn to dust? Test yourself by studying the photos of six minerals below. Are you able to match up the photos to the names listed? If you can, send us your entry. The first two people with correct answers drawn randomly from the list of entrants will each receive a high-value Garmin Forerunner® 405 GPS-enabled sports watch or a Garmin Approach S1 GPS golf watch. Good luck!

A. pollucite, B. galena, C. hematite, D. pyrite, E. gypsum, F. sulphur

Please send your entry to formate.matters@cabot-corp.com or fax (44) 1224 870089 by 15 October 2012. Your full name and organisation must be included.

Thank you to those who entered our previous competition 'Can you Sea?' where each winner could select a charity of their choice for a US$ 250 donation from Cabot. The winners are Dave Marshall of Baker Hughes, Hilary Turner of Jetta Operating Company and Angel (A.G) Guzman-Garcia of ExxonMobil Exploration. Congratulations! For the answers to the previous competition, or for the complete rules of this puzzle, please email formate.matters@cabot-corp.com.

SIGN UP FOR YOUR FREE SUBSCRIPTION!

If you would like to receive Formate Matters please send an email to formate.matters@cabot-corp.com or call (44) 1224 897229.

AND FINALLY...

"We would accomplish many more things if we did not think of them as impossible."

Vince Lombardi (1913 – 1970), American football coach

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