

# FORMATE MATTERS

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News and opinion from Cabot Specialty Fluids

www.formatebrines.com

## Formate brine passes six-year corrosion test in HPHT well



**After six years combating pressures of 14,000 psi and temperatures of 350°F (177°C) the production string was finally pulled from High Island A-5 well #1 situated about 35 miles south of Sabine Pass off the Texas coast. Remarkably, the identification markings on the pipe were still intact.**

Once it was out, the last and deepest joint of production string was examined thoroughly by Salah Mahmoud of MTL Engineering, Inc. in Houston. "Our tests show that the strength and toughness of the 13Cr tubular was unaffected by its lengthy exposure to the packer fluid, a 1.38 s.g. (11.5 ppg) sodium/potassium formate brine. The entire tubular length was also free of pitting or corrosion and there were no signs of embrittlement. Detailed microscopic examination of the tubular surface and cross-section samples also reveals that it is entirely free of any cracks or microfractures."

The formate brine that had been 'cooking' for six years at 350°F (177°C) was also in excellent condition with no change in density or buffering capacity.

When the packer was set in 2002, High Island A-5 belonged to BP. It's now owned by Apache and the decision to plug and abandon the well because of natural depletion in April 2008 provided a rare opportunity to examine the condition of the Sumitomo SM13Cr 95 ksi

production string after six years of service under hydrothermal conditions.

The original decision to replace the halide brine-based packer fluid with formate brine came after corrosion caused tubing failure. Within one to two weeks of being run into the High Island A-5 well, a 13Cr 110 ksi Hyper-Chrome production tubing string failed at a depth of 2,576 to 3,383 m (8,450 to 11,100 ft) where local temperatures were in the range of 93 to 121°C (200 to 250°F). Ed Robinson of Baroid/Halliburton, writing in *Offshore*<sup>1)</sup>, speculated that the rapid cracking of the tool joints could have been chloride stress corrosion cracking (CSCC) created by exposure to the 1.438 s.g. (12 ppg) inhibited calcium bromide/calcium chloride packer fluid. An alternative cracking mechanism considered at the time was hydrogen embrittlement created by the pipe's exposure to zinc bromide brine used previously to work the hole. This rapid cracking of 13Cr tubulars at fairly low temperatures and depths with halide brines led the operator to change

packer fluid to formate brine. At this point, although formate brines had been used successfully for HPHT operations in other parts of the world, they had only been used for one other HPHT packer fluid application in the Gulf of Mexico the year before – ExxonMobil's MO 822 #7 well at a BHST of 420°F (215°C). It was correctly believed, however, that formate brines would reduce the risk of localised corrosion and provide compatibility with the SM13Cr steel pipe.

Corrosion Resistant Alloys (CRAs), such as 13Cr steel, are chosen because they give tubulars some resistance to corrosion from any acid gases present in the production stream. Unfortunately, there have still been serious failures of CRA tubulars in HPHT wells where traditional halide brines have been used as completion and packer fluids. The majority of failures occur as brines become contaminated with corrosive gases, such as oxygen, carbon dioxide or hydrogen sulphide, which cause stress corrosion cracking (SCC). Formate brines, on the other

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"It's rare to see tubing preserved so well under hydrothermal conditions over so many years", says Salah Mahmoud of MTL Engineering, Inc. in Houston



**Pipe identification markings were still intact after six years immersed in formate brine at high pressures and temperatures**

hand, contain very low levels of halide ions, which means they are free of the corrosion problems commonly associated with halides. This helps explain the results from the High Island A5 tubular tests. As Salah Mahmoud says, "The condition of the tubular was truly remarkable when you consider what it's gone through. It's rare to see tubing preserved so well under hydrothermal conditions over so many years."

Thanks go to the Apache Corporation for providing the tubing used for testing.

*1) Source: Robinson, E.: "Thiocyanate corrosion inhibitors suspected in chloride stress corrosion cracking", Offshore, Volume 64, Issue 10, October 2004.*

**For a list of formate brine packer jobs please see page 3.**



**A question on formates? Consult our technical manual**

### Technical business

The 'formate bible' as many like to call it has grown again. This time with a new section on compatibility of formate brines with oilfield fluids, namely seawater, base oil, halide brines, OBMs, SBMs, WBMs, methanol and glycol. In addition, a significantly updated edition of Section A6 – pH and buffering of formate brines – replaces the existing version. For your updates, or an overview of all sections, please go to [www.formatebrines.com/manual](http://www.formatebrines.com/manual) or email us at [formatemanual@cabot-corp.com](mailto:formatemanual@cabot-corp.com).

# Cesium formate reaches 10-year milestone

"Come September we can celebrate ten years of cesium formate use in the oilfield", says General Manager Jim Turner, Cabot Specialty Fluids. "Shell Expro first trialed cesium formate in the Shearwater field back in 1999 followed right after by an HPHT well completion in TOTAL's Dunbar field," he continues. This was shortly followed by a series of workover and completion operations in Total's Elgin/Franklin fields with the most extreme HPHT conditions ever encountered in the North Sea. Notably, it still remains in use there today.

Since then cesium formate has been used over four continents on more than 200 HPHT jobs for the likes of StatoilHydro, TOTAL, BP, Shell, ExxonMobil, Marathon and Agip. Cabot Specialty Fluids's offices have expanded from the company's original bases in Aberdeen and Houston to include Norway, Singapore and China.

"For the first three years, cesium formate was a North Sea phenomenon," says Jim Turner. "The sharpening of HSE regulation, the growing concern about zinc bromide and the brine's technical advantages meant that cesium formate soon took centre stage as the high-density brine-of-choice in the North Sea", he continues.

It wasn't until 2002 that cesium formate travelled outside Europe, this time to the Gulf of Mexico, with BP being the first to use it on High Island A5 as a coiled tubing intervention fluid. Then came Asia with Shell, ExxonMobil



**Statfjord A: StatoilHydro has consistently used high-density cesium formate over the last nine years, including Statfjord A in the North Sea (pictured)**

and Agip KCO, and South America with Petrobras. All HPHT applications.

"There have been several milestones along the way", says Jim Turner. "The first drilling job – Statoil in its Huldra field, the first application in a field with sub-sea well heads – Norsk Hydro with Visund, the first land job – a gas well for MOL in Hungary, the most extreme HPHT subsea development – Statoil with Kristin, and recently the highest temperature use for cesium formate so far. This was

six months downhole at 235°C (455°F) for TXM in Hungary."

"We've reached where we are with a team of highly motivated professionals who have all shown real dedication in getting cesium formate accepted in a market that was originally sceptical," says Jim Turner. "The fact that we now have so many loyal customers shows that we are delivering value for money. This is perhaps the greatest reward," he concludes.

## DID YOU KNOW?

### Was this the first 'oil man'?

OK, this might be a stretch, but you're now looking at Anubis, the ancient Egyptian god of mummification. He is credited with being the first to practice the art, plays an important role in embalming rituals and is seen as the guardian of the dead and guide through the underworld. Quite a job description in other words.

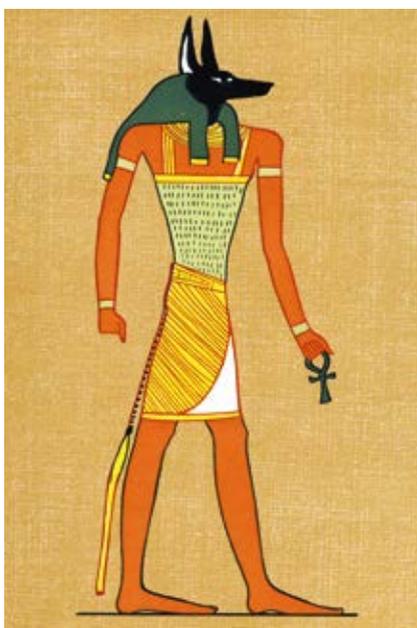
So what has this got to do with oil you may ask? Well, the word 'mummy' is derived from the Persian/Arabic word *mummiya*, meaning 'bitumen', 'tar' or 'resin'. Bitumen, derived from natural oil seeps, was often used in mummification to help preserve the corpse. In fact, with gas chromatography and mass spectrometers, source-specific

compounds – called biomarkers – can be identified in the mummy's oil to create a 'fingerprint'. This is again matched to known oil sources in the region to trace the location where the oil originated – often many hundreds of miles away from the mummy's location. Consequently, there is mounting evidence to suggest that the ancient Egyptians traded oil and other goods across the Middle East in much the same way as they are today.

Sources: 1) *Geotimes*, February 2005. 2) *Organic Geochemistry Indicates Gebel El Zeit, Gulf of Suez, is a Source of Bitumen used in some Egyptian Mummies*, Barakat, Kennicutt, et al, *Journal of Geoarchaeology*, March 2005. 3) *Australian Museum online*.



**Mummification? Tar very much**



**Anubis – the jackel-headed god of mummification**

# Agip KCO hits another six



The sun sets over 'D' island in the Kashagan field where Agip KCO is completing a further six wells in cesium formate brine

When it came to island 'D' clear solids-free cesium formate brine was put through its paces in the first well completion in June 2008. The first well was completed on schedule with the next five following in a similar manner before the winter set in last October. Fluid losses were minimal with remaining fluid suffering very little density loss. Now Agip is in the middle of the final six completions scheduled before this year's winter starts to bite.

Cabot Specialty Fluids is working as a sub-contractor to Halliburton, which has provided drilling and completion fluid support to the project since it began in 2005. Together, Cabot and Halliburton are providing cesium formate fluid and on-site fluid engineering support during the completion phase of the wells.

**Following a successful winter drilling campaign on Kashagan's 'D' island, Agip KCO is completing the remaining six wells on the island using cesium formate brine. Agip is looking to repeat or improve upon an average 12-day completion time achieved with the first six completions in 2008.**

All oilfields are unique. Only Kashagan is more unique than others. It lies in the isolated shallow waters of the northern Caspian with its teeth-chattering winters and rig-wrecking ice packs making working conditions difficult to say the least. Outside temperatures vary from -35°C (-31°F) in winter to 40°C (104°F) in summer with strong winds driving sea level variations of 3.7 metres (12 feet). And that's

just above the surface. Go underground and you encounter reservoir pressures of 800 bar (11,600 psi) and oil containing up to 20% hydrogen sulphide.

This is why credit is even more due for Agip KCO on their successful completion of six of the 12 wells on 'D' island, an artificial production base built several metres above the surface

of the sea. This is just one of many such islands. In total, approximately 300 wells are expected to be drilled to achieve oil production of 1.2 million bbl/day by 2016. Due to high pressure and tough environmental conditions Agip makes kill-weight completion fluid a prerequisite. A number of solids-laden options were tested in wells on 'A' island, the first artificial structure built in Kashagan.

## Less curiouser

In our last issue, we asked readers for their help with a puzzling result from a North Sea perforating operation (Curiouser and curiouser). In summary, the operator used a straight 1.86 s.g./15.5 ppg cesium formate brine, rather than a formulated kill pill, and yet still only lost 14 bbl of clear fluid into the formation. We asked "why?"

Our thanks to everyone who entered and particularly Don Whitfill of Baroid and Don Weintritt of Weintritt Consulting Services. Both suggested that the presence of oil-based mud residues previously bullheaded into the formation may have caused a barrier to the flow of cesium formate brine out of the perforation tunnels. In our judges' opinion, this was the most technically compelling and likely explanation for the low brine losses. Amazon.com gift vouchers are on their way to both winners.

### Why were fluid losses minimal?



## Overview of jobs using formate brines as packer fluids

Operator	Location	Packer fluid	BHT (°C/°F)	Start	Finish
Devon	WC 165 A-7	1.03 s.g./8.6 ppg K formate	149/300	2005	Ongoing
Devon	WC 165 A-8	1.03 s.g./8.6 ppg K formate	149/300	2006	Ongoing
Devon	WC 575 A-3 ST2	1.14 s.g./9.5 ppg K formate	132/270	2005	Ongoing
WOG/Devon	MO 862 #1	1.44 s.g./12.0 ppg NaK formate	216/420	4/2005	5/2006 <sup>1)</sup>
BP/Apache HI	A5 #1	1.38 s.g./11.5 ppg NaK formate	164/327	2/2002	4/2008 <sup>2)</sup>
ExxonMobil MO	822 #7	1.44 s.g./12.0 ppg NaK formate	216/420	2001	Ongoing
EPL	ST 42 #1	1.38 s.g./11.5 ppg NsK formate	133/272	2006	Ongoing
EPL	ST 41 #F1	1.56 s.g./13.0 ppg NaK formate	106/222	2006	Ongoing
EPL	EC 109 A-5	1.38 s.g./11.5 ppg NaK formate	121/250	2006	Ongoing
EPL	ST 42 #2	1.53 s.g./12.8 ppg NaK formate	132/270	2006	Ongoing
Dominion	WC 72 #3 BP1	1.20 s.g./10.0 ppg Na formate	121/250	2006	Ongoing
EPL	WC 98 A3 ST1	1.52 s.g./12.7 ppg NaK formate	153/307	2006	Ongoing
EPL	WC 98 A3	1.29 s.g./10.8 ppg NaK formate	154/310	2007	Ongoing

1) G3 tubing in excellent condition. 2) SM13Cr tubing in pristine condition.

## TECHNICAL FORUM

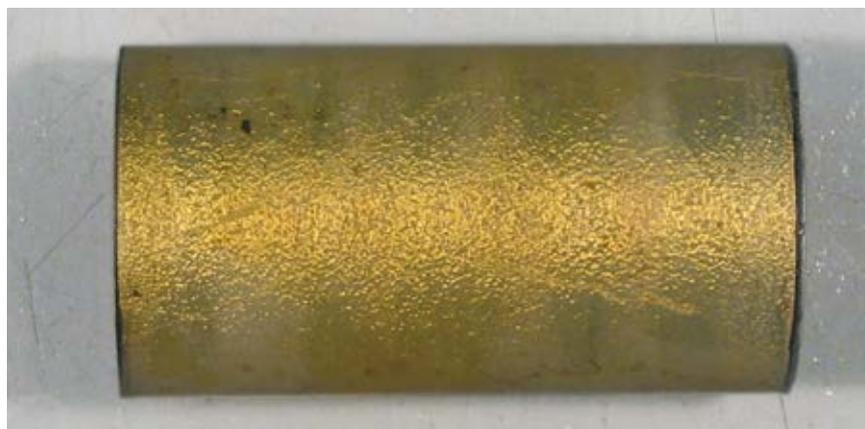
# Corex sets new Gold Standard for HPHT coreflood testing with cesium formate brine

How do you accurately measure gas permeability in reservoir core samples while conducting HPHT formation damage testing on cesium formate brine? This was the challenge facing Corex Ltd., one of the world's leading core analysis companies and experts in formation damage, when asked by Cabot to carry out HPHT core flood tests for a major North Sea operator. A review of their test procedures identified two areas of concern that could introduce errors into gas permeability determinations:

- Gas leakage from the cores through the surrounding elastomer seals at extreme temperature and pressure.
- Dehydration of core's fluid contents if the test gas is not fully saturated with water vapour under test conditions.

To solve the problem of gas leakage Corex came up with a gold-plated solution. The core was wrapped in a gas-impervious layer of 24-carat gold before fitting the elastomer sleeving and O-rings.

The second problem of dehydration was overcome through the installation of a pressurised high-temperature gas humidifier



24-carat gold film prevents gas leaking from the core under hydrothermal conditions

to ensure that gas entering the core was fully saturated with water.

Using this new test set-up Corex carried out two formation damage tests with cesium formate brine on cores from a major HPHT field located in the UK North Sea. The test temperature was 200°C (392°F) and the pore pressure inside the core was maintained at 5,800 psi. In one test, the gas used during drawdown and permeability measurements was passed through a pressurised humidifier

held at room temperature. In the other test, the gas was passed through the new pressurised high-temperature gas humidifier.

Commenting on the outcome of the tests reported in SPE paper 121649<sup>1)</sup>, Ian Patey, manager of Corex's Formation Damage group, said: "The overall permeability of the reservoir core sample to gas was unaffected by injection of 10 pore volumes of cesium formate brine, followed by a 48-hour static soak at 200°C and back-production using

4 litres (>1,000 pore volumes) of HPHT humidified gas under 100 psi drawdown. In the other test permeability was reduced by nearly 15%. This shows that full HPHT humidification of the gas phase results in higher gas return permeability when compared with a comparative test using gas humidified at room temperature and high pressure. Consequently, it's critical that gases used in HPHT core flooding tests are fully saturated with water vapour at the test temperature and pressure to ensure correct and realistic results."

This innovative use of gold-coated cores and HPHT humidified gas sets new levels of accuracy for core flood testing of high-density completion brines at high temperatures. It also helps match laboratory test results with operators' experience of using cesium formate brines in HPHT wells over the last ten years.

*Downs, J.D.: "Observations on Gas Permeability Measurements under HPHT Conditions in Core Materials Exposed to Cesium Formate Brine", SPE 121649 presented at 2009 SPE European Formation Damage Conference, Scheveningen, The Netherlands, 27-29 May 2009.*

## Making a statement

How are you at anagrams? To help you answer the question we've put together six of them in the box on the right. **Each anagram consists of two words and together they make a statement that sums up our product.** Once you've solved the puzzle please send us your completed entry and we'll enter you for our prize draw. The first **five** participants with the correct answers chosen randomly from the entrants' list wins the Forerunner 201 from Garmin, a personal training device with GPS that measures speed, distance, pace and calories burned. Best of luck!

Please send your entry to [formatematters@cabot-corp.com](mailto:formatematters@cabot-corp.com) or fax (44) 1224 870089 by 1 October 2009. Congratulations to all those who solved the Code Breaker puzzle in the previous issue of Formate Matters. The lucky winner is Scott T. Austen of Hanley and Bird. For the correct answer to Code Breaker, or for the complete rules for this competition, please email [formatematters@cabot-corp.com](mailto:formatematters@cabot-corp.com).

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 PUSH RIGS HERE  
 HUGER HEAT PERMIT  
 I FIND DULL GIRL  
 BIONIC PETROL MEN  
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### AND FINALLY...

**"There are two things I really like about my job. When the phone rings I never know where I'm heading to next - and I'm never bothered by life-insurance salesmen!"**

Red Adair, American oilwell firefighter, 1915 - 2004

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