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Field of View

Issue # 1: Spring 2020

The latest news, insights and innovations from Rawwater

In this edition:

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Welcome to the very first edition of 'Field of View'

– the digital newsletter from Rawwater

With so many exciting things happening at Rawwater, now seemed the perfect time to launch 'Field of View' – a short, infrequent, yet hopefully informative newsletter specially produced to keep our customers, colleagues, associates and friends up to speed with our activities, insights and innovations.

In this first edition, we investigate the causes of microbiological oilfield souring, explore the use of our pressurised bioreactors in replicating downhole pressure and temperature conditions – and discuss our creation of the world's first 'anticipated' 3,000-year-life cast metal seal for plugging & abandonment activities.

Looking ahead, we plan to bring you news of our achievements in oilfield reservoir souring and simulation forecasting and our use of Rawwater Bismuth Plugs for oil and gas reservoir plugging & abandonment. We are also developing Molten Metal Manipulation (M^3) – an innovative range of new alloys and application techniques to provide high integrity, reversible metal seals for the nuclear industry and other sectors. Watch this space!

Most important of all, we promise never to 'spam' you. Understanding just how very busy you are, we will only send you future editions of our newsletter when we have something of genuine interest to say.

We hope you enjoy reading 'Field of View' and look forward to catching up with you during the coming year.

With best wishes,

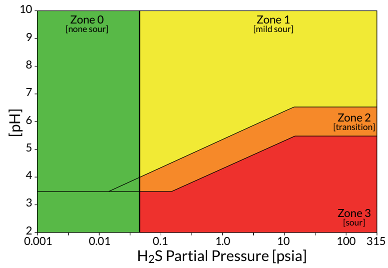
Professor Robert (Bob) Eden PhD
Rawwater Founder and Managing Director

Sweet or sour?

Investigating the causes of microbiological oilfield souring

Whether through native geology or geochemistry, sour crude is common across all oil producing regions of the world. Unlike sweet crude, which typically contains below 5% sulfur, sour crude has a higher percentage of sulfur – an impurity which can make its presence known through acrid, highly corrosive hydrogen sulfide (H_2S) gas.

Compared to sweet oil, sour crude is more expensive to refine, presents a significant corrosion risk to assets and incurs higher chemical treatment costs. Therefore, what makes a previously sweet oil environment turn sour – and why can higher levels of hydrogen sulfide be observed in a reservoir that already has a degree of souring? The answer lies in a phenomenon known as **microbiological oilfield souring**.



NACE diagram for sour service point

Introducing sulfate-reducing microorganisms

Additional downhole pressure is necessary to successfully extract oil throughout the lifespan of a reservoir – and this is typically achieved by injecting water (often sulfate-rich seawater) during secondary recovery operations. The injected water will introduce sulfate-reducing microorganisms (SRM, often also referred to as sulfate-reducing bacteria or SRB) into the reservoir environment and can even propagate microbial lifeforms that are already present downhole.

The conditions necessary for microbial life

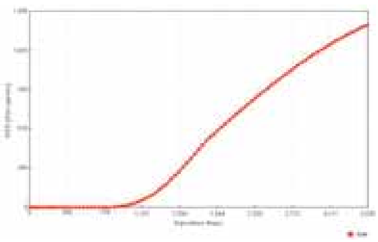
To flourish, SRM require water, sulfate (which is chemically reduced and converted to sulfide), an anoxic (oxygen-free) environment and an energy source (typically the volatile fatty acids (VFAs) and the residual crude oil). Add a pH of 4 to 9, a temperature of 10°C to 80°C and a pressure range from 1 psig to 10,000 psig, and the elements are in place for sulfate-reducing microorganisms to flourish, leading to increased concentrations of H_2S at the topsides facilities over time.

Typically, if unchecked, microbiological reservoir souring goes unnoticed until higher concentrations of hydrogen sulfide are detected in crude oil production. This is because several years of secondary recovery activities may be required before higher levels of H_2S are observed. For cost-effective treatment, it is therefore important to forecast an oil reservoir's ability to sour at the earliest possible opportunity.

> Sour crude is more expensive to refine, presents a significant corrosion risk to assets and incurs higher chemical treatment costs.

DynamicTVS©

To assist operators in understanding whether or not their oilfields will sour – and to ensure any risk of souring is identified early enough to allow for economical treatment – data from our pressurised bioreactor studies is used to calibrate DynamicTVS© (TVS = Thermal Viability Shell), our predictive oilfield souring tool. Able to forecast a reservoir's propensity to sour in advance of well completion, the DynamicTVS© model describes the cooling of an oil reservoir due to water-flooding, the opportunity for growth of sulfate-reducing microorganisms (SRM) in the cooled zone, the transport of the hydrogen sulfide produced by the SRM to the producer, and the downhole and topsides partitioning of the sulfide at specified pressures and temperatures.



Typical sour profile output from DynamicTVS©

Taking operational, planning and survey data from all stages of oil production, under any temperature and pressure conditions, DynamicTVS© is used to generate future profiles of hydrogen sulfide in all fluid phases. DynamicTVS© was developed at UMIST – the University of Manchester Institute of Science and Technology. To date, we have completed more than 130 souring forecasts, including single injector/producer (I/P) pair forecasts and full-field statistical analysis, for clients worldwide.

Rawwater pressurised bioreactors

Replicating the pressures and temperatures that are found downhole

Recognising the conditions that are necessary for microbiological oilfield souring is critical to accurately forecasting whether or not an oil reservoir will sour. It is for that very reason, research teams at our UK-based technology centre use pressurised bioreactors – specially designed corrosion-resistant columns – to simulate the pressure and temperature conditions that are found in water-flooded oil reservoirs. By doing so, they assist oil operators in making the right commercial decisions with regard to souring control.

We have been sub-culturing oilfield microorganisms for more than 30 years and, since 2006, have operated what is widely considered to be the world's largest and most advanced research facility to study and evaluate microbiological souring in simulated reservoir conditions. Our research concerns the behaviour of sulfate-reducing microorganisms (SRM) and the control of SRM through injection water treatments, including nitrate and proprietary chemical dosing.

Almost 500 years' worth of oilfield souring data

As many as 85 pressurised bioreactor columns, ranging from 25 cm to 4 metres in length, are in daily operation at our research facility. To date, we have accumulated the equivalent of almost 500 bioreactor years' worth of oilfield souring data. This priceless dataset is growing on a daily basis and contains information relevant to oil reservoirs around the globe.

As many as 85 pressurised bioreactor columns, ranging from 25 cm to 4 metres in length, are in daily operation at our research facility.

Samples from major oilfields globally

Our souring studies use crude oil and seawater samples from major oilfields globally. Ranging from large-scale joint industry projects (JIPs) to single-client activities, they last from a matter of weeks to a number of years. To replicate the downhole world, testing conditions within our bioreactor suites range from atmospheric pressure to 12,000 psig, with temperatures ranging from 5°C to just below the boiling point of water. This considerable capability enables us to determine the efficacy of various biocides and water treatment regimens upon different microbial populations.

The Seriatim joint industry project

We first began using pressurised bioreactors in 2003 to investigate the effects of pressure and temperature on oilfield microbiology. Oil majors and service companies quickly recognised the value of our work. Their interest led to the development of our pressurised bioreactors as a research tool for the global oil and gas industry. The Seriatim joint industry project into oilfield souring was born – supported by almost $10 million in funding – and we have conducted Seriatim series research ever since.

Before the advent of Rawwater's pressurised bioreactors, investigations into whether or not an oilfield would sour as a result of microbiological activity relied on the use of simple sand, oil and seawater bottle tests, or upflow sand packs that were subjected to atmospheric pressure. Although more than suitable for simple screening programmes, such tests could not simulate the pressures and temperatures found within oil reservoirs. By contrast, the data generated by our pressurised bioreactors cover a range of operating conditions, including accurate chemistries at pressure and temperature.

A world-first for Rawwater:

The 3,000-year-life underwater cast metal seal

Our Engineering Division has created the world's first 'anticipated' 3,000-year-life underwater cast metal seal for plugging & abandonment applications. The metallurgy has been certified by Bureau Veritas as fit-for-purpose for extreme life applications in the oil and gas industry and qualified to the V0 (highest rating) of ISO 14310.

A pedigree of expertise

Recognising the need for a specialist alternative oil well plugging medium to cement, we have been investigating the use of bismuth alloys as a plugging medium for almost twenty years. We invented the Bismuth Plug and have built a large corrosion and creep database regarding the use of underwater cast bismuth alloys. We have also conducted research which underpins our belief that the development of bismuth alloys provides the opportunity for a significant reassessment of current approaches to well abandonment in particularly challenging applications, including resealing failed abandonments.

Rejecting common bismuth alloys, we have produced a suite of proprietary expanding metal alloys for use as high integrity seals in oil well abandonment. The alloy properties of low melting point and expansion upon solidification enable these high integrity seals to be cast in-situ, without the inherent creep issues typical of bismuth tin.

7" alloy plugs rated to 6000 psi for North Sea deployment

To ensure offshore capability and extreme reliability, we have completed a two year programme to deliver 7" alloy plugs for deployment in the North Sea, rated to 6000 psi differential pressure at 60 cm (2') in length. Extensive development and testing took place in collaboration with an operator consortium and the UK Government to develop the formulation of the metal seals. To establish mechanical properties and creep behaviour under service pressure and temperature conditions, we partnered with the University of Aberdeen, through an Oil & Gas Innovation Centre (OGIC)-funded partnership.

> We have a suite of proprietary expanding metal alloys for use as high integrity seals in oil well abandonment.

Operating envelopes to 160°C

The result of our research is a suite of alloys for onshore, offshore and subsea plugging & abandonment, with operating envelopes to cover downhole geothermal temperature conditions from 158 -194°F (70 – 90°C) and 284 – 320°F (140 – 160°C). Meeting the 3,000-year design life specified by Oil & Gas UK for plugs in the North Sea, these alloys have been subjected to a strict technical qualification programme overseen by Bureau Veritas, with stringent adherence to the qualification processes stipulated by DNV-RP-203 – Jul 2013, ISO 14310 (V0) and Oil & Gas UK. They are intended as a cost-effective alternative for sealing well abandonments and resealing failed abandonments that were previously plugged using cement. The application includes both casing plugs and plugs/seals in undefined and/or rough walled geometries (e.g. cap rock) that are difficult to seal with existing technologies such as cement.

Why bismuth alloys?

Low melting point alloys such as bismuth can be applied easily with little heat input to the substrate. The low viscosity of the molten alloy enables penetration into porous substrates with pore throats as tight as 25 microns, with expansion on solidification giving a tenacious gas-tight seal.

The high density of the alloy displaces water to enable sealing underwater or against large leaks, while at the same time being easily removable by re-melting if required. The bismuth casting process takes hours, as opposed to days for cement to set. As an example of the capabilities of bismuth alloy, a 3’ (0.91 metre) bismuth plug can outperform a conventional cement seal, which - by comparison - may be up to 500’ (approximately 150 metres) in length.

Appointed Honorary Professor in Earth and Environmental Sciences

We’re delighted to announce that our Founder and Managing Director, Dr Bob Eden, has been appointed as an Honorary Professor in the Faculty of Science and Engineering, within the Department of Earth and Environmental Sciences at The University of Manchester. Bob’s appointment commenced on 1st August 2019 and was made in recognition of his work in the field of well integrity and geomicrobiology.

Before establishing Rawwater almost 20 years ago, Bob worked at UMIST, where his technologies included corrosion, subsea engineering and oilfield souring. Within these areas, he raised several millions of pounds, attracting funding from the major North Sea oil operators, the USA, South America, the Middle East, and the British and Norwegian governments.

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“I am truly delighted to have been made an Honorary Professor within the Department of Earth and Environmental Sciences at The University of Manchester. Thoroughly understanding human impact on the geosphere and biosphere is essential to the future wellbeing of our planet, and I look forward to working with the Department’s distinguished staff, as well as assisting its students who, no doubt, will become the next generation of leading scientists and entrepreneurs in these fields.”

Professor Robert (Bob) Eden
Founder and Managing Director, Rawwater Engineering Company Limited

Rawwater moves into the Japanese nuclear sector

Taking our expertise in metal-to-metal plugging technologies for oil and gas reservoir abandonments a stage further, we are currently developing Molten Metal Manipulation (M^3) – a range of new alloys and application techniques to provide high integrity, reversible metal seals for the nuclear industry, defence, humanitarian aid and a range of other sectors.

Rawwater's metal sealing technology being demonstrated at NNL

As part of our research, we have been adapting our specialist alloy seals to support decommissioning challenges at the UK's Sellafield nuclear site. This has led to a significant project from major Japanese energy operator Tokyo Electric Power Company (TEPCO) exploring the possible use of M^3 technology across its nuclear power plants.

The TEPCO project was brokered by the UK's National Nuclear Laboratory (NNL) who will monitor our work and produce independent reports. These reports will also include results from demonstrations of M^3 at NNL's Workington facility in Cumbria.

The M^3 process can seal large openings or fill micron-sized cracks or pores, preventing fluid leakage. Applied underwater or in the air, it can stabilise a structure and provide radioactive shielding. Other key features include reduced recovery costs and extreme longevity.

We made the transition into the nuclear sector through Sellafield's Game Changers – an innovation programme designed to identify and develop technologies that can offer significant, pioneering advances in the decommissioning of the Sellafield nuclear site. Game Changers is delivered by NNL and FIS360, specialists in supporting innovative technologies from concept to commercial production.

The TEPCO agreement follows earlier success and recognition of our Molten Metal Manipulation (M^3) technology by the Ministry of Defence. We are working with the MoD to engineer M^3 into a portable backpack that would provide instant, emergency metal repairs for use on the front line. The kit would enable military personnel to spray a patch that solidifies immediately over a damaged surface. It means, for example, that troops could instantly repair a fuel tank damaged under fire without having to empty the tank.

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We're busy putting the finishing touches to a new website that will provide an even greater insight into our capabilities in the fields of oil reservoir souring control, well integrity and Molten Metal Manipulation (M^3). Our new website goes live in March – so please take a look. To find out more about our services and technologies, please email: info@rawwater.com

H_2S H_2S H_2S P&A M^3I M^3E M^3D M^3N

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