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Successful Mothballing and Pickling of Pipelines and Storage Tanks

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ABSTRACT

Pipelines and storage tanks are susceptible to corrosion due to bacteria and oxygen. Bacterial populations in source waters and stagnant waters as well as create bio films that attach to pipelines and storage tank walls. Sessile biofilms may contain acid producing bacteria (APB) or sulfate reducing bacteria (SRB). SRBs can generate hydrogen sulfide that will react with iron to form iron sulfide. Before placing pipelines and storage tanks out of service. It is important to choose chemicals that can prevent oxygen and acid gas corrosion and keep microbial populations in control.

In this paper, laboratory data on the use of chemicals in long duration tests simulating pipeline hydrotest conditions are provided. Procedures to preserve flowlines and storage tanks with waters of different salinities are presented. Examples of successful preservation of several pipelines are provided for several years that demonstrate successful preservation with the use of these chemicals

Key words: Pipelines, storage tanks, corrosion, acid producing bacteria, sulfate reducing bacteria, hydrogen sulfide, iron sulfide, oxygen corrosion, acid gas corrosion

INTRODUCTION

Wet-layup is a cost effective layup procedure, often referred to as “mothballing”.¹ Often material degradation occurs at higher rates in oil and gas facilities that are not in service than in operation.² Higher corrosion rates have been seen in untreated pipelines after hydrotesting.³ Several failures have occurred when untreated water used for hydro testing has been left in the pipeline after completion of the testing.⁴

Corrosion occurs due to microbes, oxygen, and under-deposit conditions.⁴ The source of water, presence of solids, temperature, and dissolved oxygen concentrations affect the corrosion tendency of hydrotest water.⁴ Many times one has to use brackish water for hydrotesting due to the difficulty of obtaining better sources of water.⁵

In this paper, laboratory data on the use of chemicals in long duration tests simulating pipeline hydrotest conditions are provided. The laboratory data comes from experiments done in 2001 by our company.⁶ Procedures to preserve flowlines and storage tanks with waters of different salinities are presented. Examples of successful preservation of several pipelines are provided for several years that demonstrate successful preservation with the use of these chemicals.

EXPERIMENTAL PROCEDURE

Long term field evaluations were carried out in test cylinders made from sealed pipeline lengths that were periodically monitored.⁶ One test cylinder contained uninhibited sea water, while the sea water in a second cylinder was treated with an oxygen scavenger, a biocide, and a corrosion inhibitor.⁶ The water was first treated with oxygen scavenger at a relevant stoichiometric amount. The treated water was then held for 15 minutes to allow the scavenger to react with oxygen. At this point biocide and corrosion inhibitor were introduced in the treated water. The outdoor tests were carried out in a temperate climate where the cylinders were subjected to ambient temperature fluctuations. Monitoring consisted of linear polarization resistance (LPR) measurement to measure the instantaneous corrosion rate, measurements of the soluble iron concentration in the fluids in the cylinder, and sulfate reducing bacterial (SRB) enumeration (by the API RP 38 method), each taken periodically over 33 months. The API RP 38 method involves using an anaerobic culture medium that is dispensed into a 10 mL serum bottle. Iron is added to each bottle and sealed with special rubber, covered "stoppers" and sterilized. One mL of a water sample from the system being tested is injected into the first serum bottles. The water is injected through the stopper by means of a disposable pre-sterilized syringe. The bottle is shaken vigorously and the syringe is discarded. After this is completed one mL of solution is withdrawn from the first bottle with a disposable pre-sterilized syringe and injected into the second bottle and the syringe is discarded. The second bottle is shaken vigorously, and a third bottle is injected with 1mL from a fresh syringe. This process is repeated serially for whatever diluted concentration is required. The bottles are then incubated for at least 28 days at a temperature within 5°C (9°F) of that of the water at the time of sampling. Development of a black color denotes the precipitation of iron sulfide and thus the presence of sulfate reducing bacteria. (Bottles which turn black within 2 hours are not to be considered positive since this will probably be due to the presence of sulfide ion in the water sample.) The concentration of SRB's in the original water sample is indicated by the number of bottles which become black. If nine bottles are positive then the concentration of bacteria colonies in the first bottle may be on the order of 10^9 colonies/mL. The rate of oxygen depletion in air saturated waters was measured in test cylinders made from sealed pipeline sections of various diameters containing fresh water and sea water. In addition, the effect of the reaction of oxygen with the pipe wall was assessed over a period of time. The effectiveness of selected chemical was assessed in laboratory studies over

an extended period of time in both fresh water and sea water. The stability of a biocidal formulation containing glutaraldehyde was examined when placed in fresh and sea water at ambient temperature (20 to 22°C). High Pressure Liquid chromatography (HPLC) with a Ultraviolet detector (UV) was used to measure the concentration of the biocide in these studies.⁶

RESULTS

The results of monitoring corrosion rate using LPR in the two test cylinders are shown in Figure 1.⁶

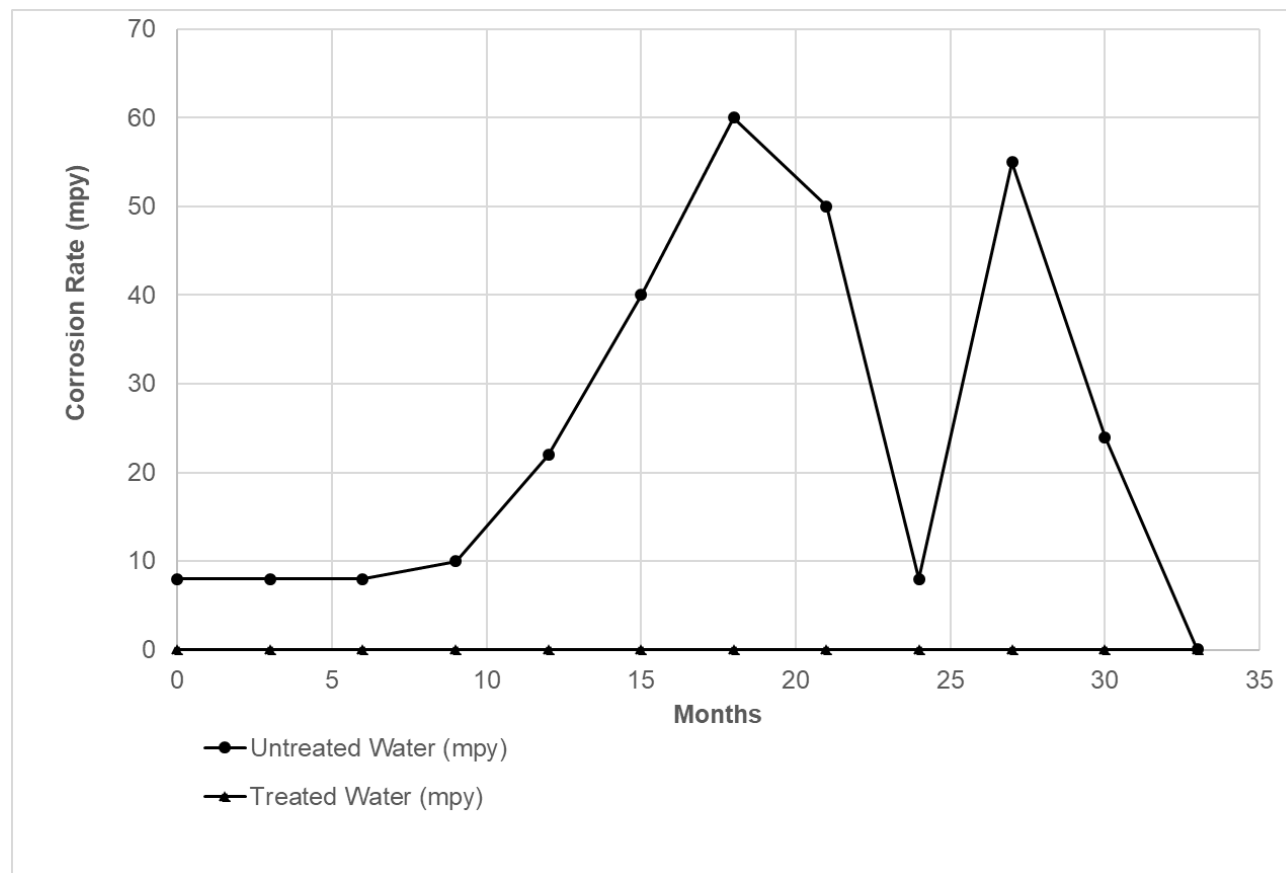


Figure 1: Corrosion Rate in cylinders containing untreated water and treated water for 33 months

The tests were conducted outside in a temperate climate where the cylinders were subjected to ambient temperature fluctuations. Test cylinder 1 contained untreated sea water, whereas the sea water in cylinder 2 was treated with an oxygen scavenger, biocide, and corrosion inhibitor. From Figure 1, the corrosion rate in cylinder 1 fluctuates widely between 8 mpy (0.2 mm/yr) and 59 mpy (1.5 mm/yr), the peaks occurring in the summer months when the ambient temperatures are the highest. The treated cylinder showed very low corrosion rates in the 0.04 to 0.08 mpy range (0.001 to 0.002 mm/yr). This indicates that treatments with oxygen, biocide, and corrosion inhibitor decreases corrosion rates to acceptable values.

A measure of bacterial activity can be gained from Figure 2 which shows a plot of soluble iron concentration in the water versus time.⁶

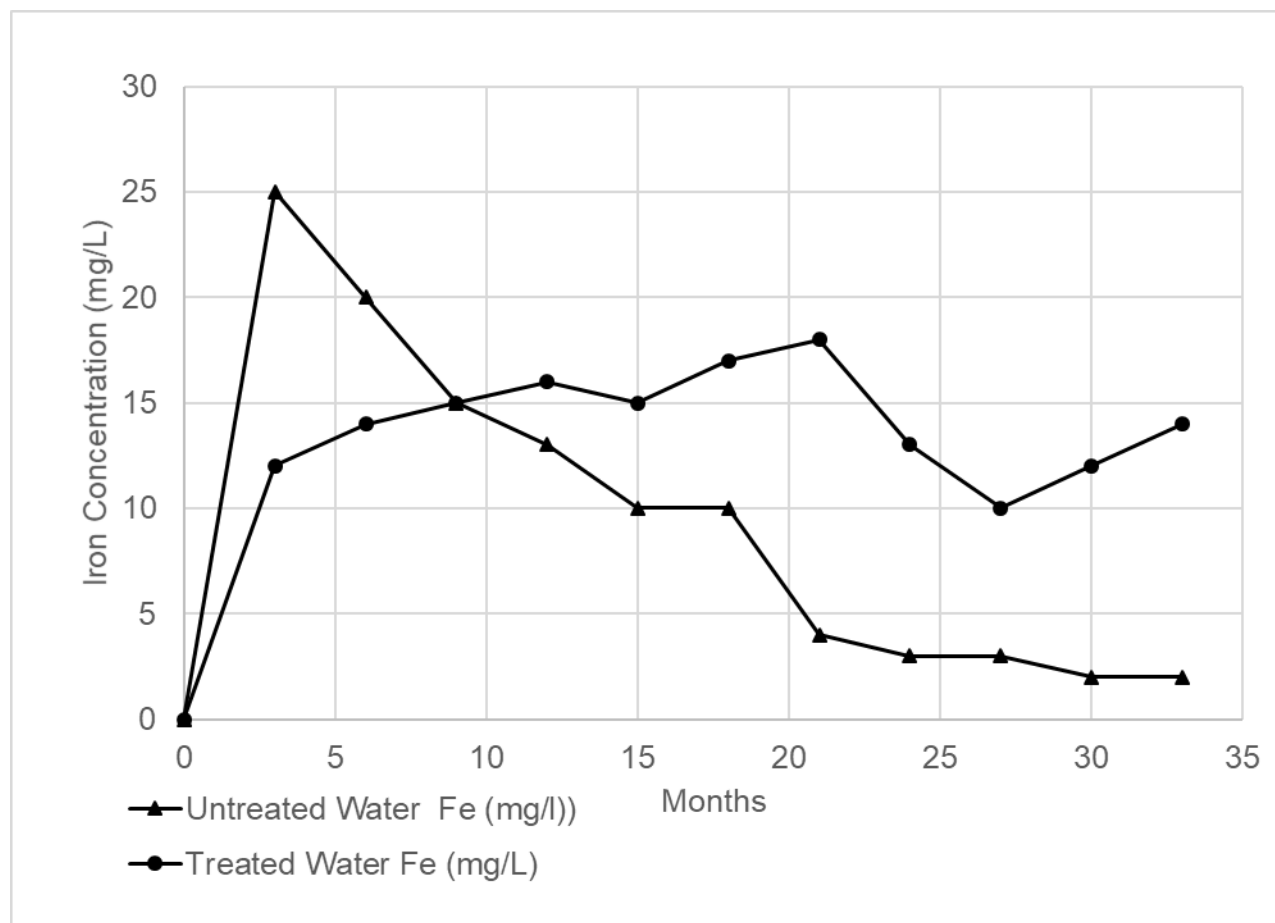


Figure 2: Dissolved iron concentration in cylinders containing untreated water and treated water for 33 months

In the treated cylinder, the iron level remains relatively constant at 10 to 20 ppm; however, in the untreated cylinder, the soluble iron concentration rises initially up to 25 ppm and then falls to below 2 ppm. This is likely caused by the precipitation of insoluble iron sulfide, which is a result of dissolved iron reacting with hydrogen sulfide produced by SRB growth. The numbers of SRBs in the pipeline test cylinders over are shown in Figure 3.⁶

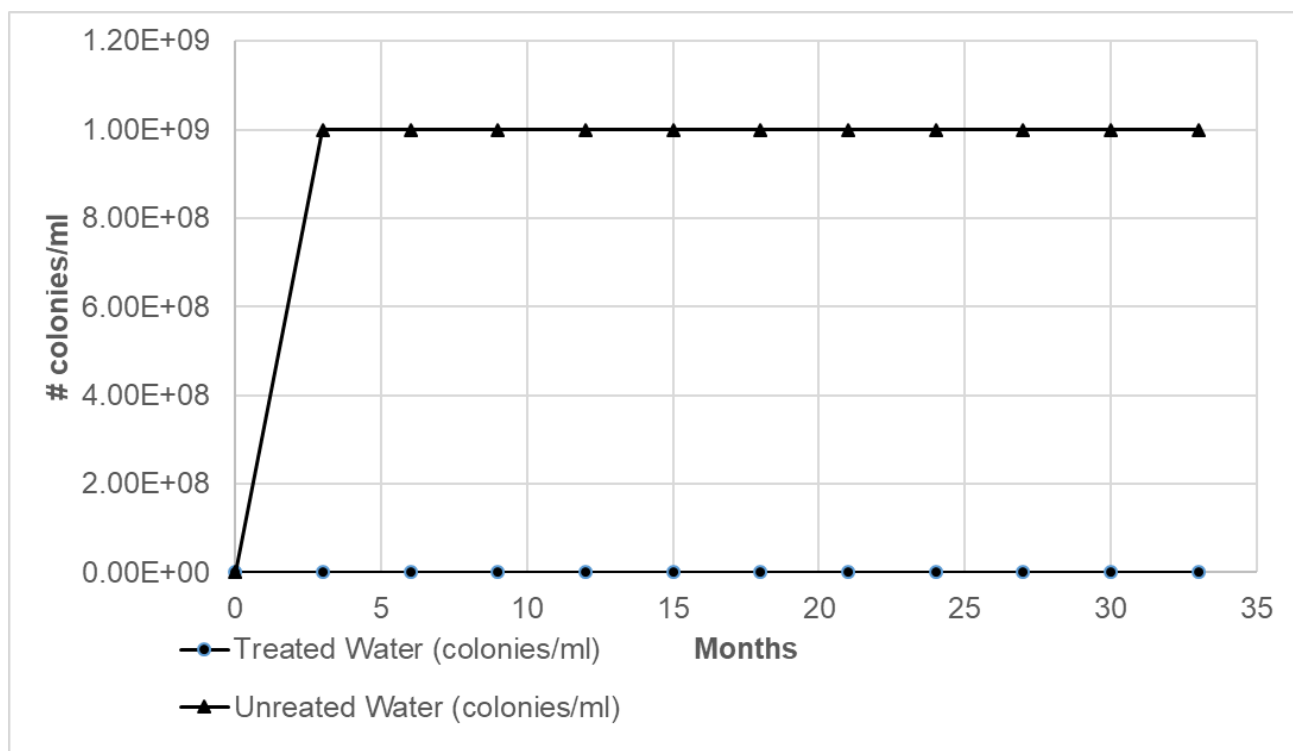


Figure 3: Estimated SRB concentration using API RP 38 method from samples obtained from cylinders containing untreated water and treated water for 33 months

In Figure 3, the SRB levels rise to a constant 10^9 colonies/mL in the untreated fluid, whereas they remain zero in the treated cylinder. This rise coincides with the decrease in iron in Figure 2. This shows that not treating a system with biocides can create massive amounts of bacteria in a pipeline. As mentioned above, high levels of bacteria are known to be corrosive to pipeline steels.⁴

The time required for oxygen depletion to approximately 100 ppb in both fresh and sea water in a range of pipe diameters is shown in Table 1.⁶

Table 1: Oxygen depletion in water filled pipelines, Experiments done between 20 to 22°C

Pipe Size (mm)	Water Type	Initial O ₂ concentration (ppm)	Time to reach 100 ppb (Hours)
250	Fresh	7.2	48
100	Fresh	6.8	26
50	Fresh	7.0	20
250	Sea	4.5	48
100	Sea	4.0	30
50	Sea	4.5	18

The oxygen in the largest diameter (10" or 250 mm) cylinder was depleted in 48 hours. Metal coupons suspended in the water in the cylinders were examined after 4 months for signs of oxygen attack. No evidence of pitting was observed.

The stability of a biocide containing glutaraldehyde was studied for thermal stability when placed in a test cylinder made of pipeline material. The concentration of the biocide was measured at regular intervals during the test. The results of the testing are shown in Figure 4.⁶