

Fast-acting Post Hydrotest Batch Chemical Treatment for Large Pipelines

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ABSTRACT

Newly constructed long-distance pipelines are often hydrotested with water from a natural reservoir without the use of chemical treatment. Chemicals are typically not used for various reasons: (i) the water is usually released back into the natural environment after use, (ii) the environmental impact of a chemically treated water release during hydrotesting is higher than an untreated water release, and (iii) the volume of water used to hydrotest long distance pipelines are too large for economical chemical treatment. It could take months before the hydrotested pipelines are put into service leading to potentially severe internal corrosion risk due to residual water and associated corrosion factors such as oxygen, salts, solids and microbes. Such risk can be reduced by conducting a batch chemical treatment with corrosion inhibitors and biocide. There are several key challenges for batch treatment of corrosion inhibitors: (i) low contact time during the batching process (e.g., 10 seconds) requiring fast acting and persistent inhibitors, (ii) vapor phase inhibition in situations when batched inhibitor does not

wet the entire pipe surface, (iii) impact of brine chemistry, (iv) maintain inhibition at low concentrations for situations where batch pill is diluted as it picks up stagnant water in the pipe, (v) impact of inhibitors on refinery operations when residual inhibitor is carried with crude oil and (vi) HSE risks associated with the presence of residual inhibitor on the pipe wall and vapor spaces. This HSE risk is an especially difficult challenge to resolve. Here we report results of a laboratory study to investigate inhibitors to address these challenges. Corrosion in fluid, headspace and interface was measured by suspending coupons. Biocide compatibility was studied by ATP tests. Impact of inhibitor crude oil carryover on refinery processes was conducted with a battery of harms tests.

Key words: Internal corrosion, hydrotest, pipeline, corrosion inhibitor, persistency, batch inhibition

INTRODUCTION

Pressure testing is a standard practice used to validate the condition of new pipelines (prior to wet commissioning) and may also be used to revalidate the integrity of older pipelines. Since water is the primary medium for pressure testing, the process has been termed hydrostatic testing or hydrotesting. While the low cost, accessibility and environmental impact are primary drivers for use of water, the inherent corrosiveness of water poses an asset integrity challenge.¹⁻⁴ The quality of the water (from brackish to potable water), the duration between hydrotest and commissioning, and the reuse of test media in multiple pipe sections play a major role in the degree of corrosion that is possible. Primary corrosion factors include oxygen, microbes and deposits. These factors can be countered by applying chemicals treatments including oxygen scavengers, corrosion inhibitors and biocides.⁵⁻¹²

The practicality of chemical treatments is dictated by (i) chemicals costs, (ii) availability of storage for treated water and (iii) waste disposal costs (if the used hydrotest media is unsuitable for overland discharge or reinjection into the water source). The treatment economics are very different for small vs large pipelines. As an example, a 10km 0.1m diameter requires treatment of only 79 m³ of water. In contrast, a large 50 km 0.75m diameter requires treatment of 22,000 m³ of water. While treating the hydrotest water for former 79m³ pipeline is economical, it is not practical to treat the latter 22,000 m³ pipeline. For large volume pipelines, an effective and economical option is to hydrotest with untreated water followed by dewatering and a batched chemical rinse with a highly treated water to mitigate corrosion.⁴

This study provides a laboratory procedure that pipeline operators can reference to demonstrate the ability of post hydrotest chemical batch treatment to reduce corrosion in the liquid and vapor phases. The consideration of both phases is important as there is the potential for the pigs to separate during the batch and as a result the top surface of the pipeline may not be directly exposed to the chemical treatment. Additionally, complicated piping systems (including station facilities) may preclude full liquid contact of a post hydrotest chemical treatment.

This study shows how multiple products are screened for use in simulated hydrotest water based on the corrosion rate in the treated medium. The focus in this study is to achieve the highest level of corrosion protection using the lowest dosage possible. The owner/operators goal is to identify the product with the lowest cost to treat, however economics is not considered in this study. In this study, it can be inferred that the lowest dosage (best inhibitor) likely offers the lowest 'cost of treatment' due to the range of performance observed.

EXPERIMENTAL PROCEDURE

Weight loss study simulating post hydrotest chemical batching.

Preparation of coupons.

A synthetic brine was prepared by dissolving the following salts in deionized water: 0.140grams/L or g/L of potassium chloride (KCl), 0.555 g/L of sodium bicarbonate (NaHCO₃), 0.208 g/L of calcium chloride

dihydrate ($\text{CaCl}_2 \cdot 2\text{H}_2\text{O}$) and 0.151 g/L of magnesium sulfate heptahydrate ($\text{MgSO}_4 \cdot 7\text{H}_2\text{O}$).¹³ Pipeline carbon steel 5L X70 material coupons (1 1/4" Length x 1/2" Width x 1/8" Thick with 1/4" diameter hole) were immersed in the synthetic brine for 48 hours to simulate hydrotesting without the use of any chemicals as shown in Figure 1. Corrosion resistant alloy (CRA) wire was used to hang the coupons. The large anode (coupon) to cathode (CRA wire) ratio reduced potential for galvanic corrosion. Plastic zip ties could also be used to hang coupons to completely prevent galvanic corrosion. When a different brine needs to be studied such as the actual water source, coupons can be prepared in the same manner as Figure 1 with the respective brine prior to testing post hydrotest chemical treatment.

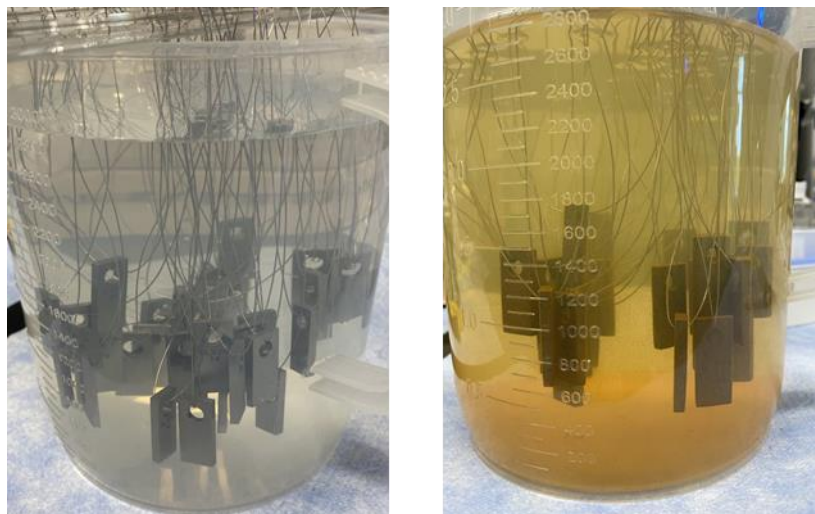


Figure 1: Carbon Steel Coupons immersed in synthetic brine at start (left) and after 48 hours (right) to simulate hydrotest without use of chemicals.

Bottle test to simulate post hydrotest corrosion inhibitor treatment

The corrosion inhibitor solution was mixed at various volume percentage levels with the synthetic brine for the post hydrotest batching study. Each test was conducted in a one-liter glass bottle that was half filled with the post hydrotest batching chemical solution as shown in Figure 2. A hole was introduced in the cap to allow unlimited inventory of air/ oxygen. Four coupons were suspended from the metal cap on CRA wires. The first coupon was completely immersed in the solution to simulate corrosion in the solution that accumulates at the bottom of the pipe. The second coupon is half immersed to mimic interfacial corrosion that occurs at the liquid vapor interface. The third coupon was immersed in the chemical solution for 10 seconds followed by suspension in the headspace. This third coupon models bulk of the pipeline surface that is batch treated with the chemical solution between two pigs with a surface contact time of 10 seconds. Finally, the fourth coupon is suspended in the headspace without any contact with the chemical solution to simulate situations where the batching solution fails to fully wet the top of the pipe when both pigs move away from each other due to poor control such as over mountainous terrain. This fourth coupons measures the vapor phase corrosion inhibition. All coupons were aged in the bottle for a period of 21 to 25 days. At the end of the test, coupons were collected and cleaned by a standard bead blasting procedure to determine the weight loss. Coupons pictures were collected both before and after cleaning to record visual observations about localized corrosion and pits.

This generalized method can be adapted to accommodate specific application needs such as aging at different temperatures or for longer durations. Additionally, although not shown here, the method can be further developed to include under deposit corrosion by introducing solids (primarily iron oxides such as those generated in Figure 1, right) in the bottle along with carbon steel beads.^{14, 15}