

The Necessity and Challenges of Using a Float Coat for Preservation of Large Volume Storage Systems

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ABSTRACT

Traditional water treatment methods pose several challenges to large-vessel preservation. The economics of continuous dosing and environmental restrictions concerning the disposal of treated water need to be considered. One solution to these challenges involves the application of an immiscible corrosion inhibiting oil partition on the water surface (henceforth referred to as a “float coat”). This paper will highlight challenges of traditional preservation methods and examine the efficacy of one commercial float coat (henceforth referred to as “Product A”).

Key words: Water Treatment, Preservation, Float Coat

INTRODUCTION

Large vessel preservation is typically accomplished through one of two methods: chemical treatment of water during hydrotesting or heavy-duty epoxy coating systems. These treatment systems have proven to be effective. However, novel approaches to large vessel preservation provide an opportunity to overcome challenges involved with more traditional preservation methods.

Chemical Treatment

Aboveground storage tanks (ASTs) in the petroleum industry come in a wide variety of sizes, ranging from modest sizes of 200 m³ up to storage volumes in excess of 100,000 m³.¹ For even the most modest dosage rates of chemical treatment at 500 ppm, costs can exceed to \$2.5 million for more than 115 m³ of chemical treatment.

Coatings

Coatings can be separated into removable, or “temporary” coatings, and permanent coatings. After the application of either type of coating, the proper amount of cure time must be allowed for the coating to achieve peak performance. Typical recommendations call for one week of cure time. During this time, no maintenance or testing can be performed on coated areas, resulting in lost time and productivity.

For tanks with a 91.4 m diameter and 18.3 m wall height¹, the total wall surface area is approximately 5300 m². Given a spread rate of 3.7 m² per liter, over 1500 liters of the coating are required, costing upwards of \$40,000 USD. While removable or temporary coatings typically cost less than permanent coatings, the reapplication of any coating for long term preservation would require significant labor cost for surface preparation and application. Finally, lost time (for product application and cure time) is also a considerable factor resulting in lost profits.

Waste Disposal

Waste disposal and environmental concerns can be very large factors in determining the efficacy of any procedure whose processes produce any amount of potentially hazardous chemical waste. The cost to properly dispose of “dirty water waste” ranges from \$0.04 to \$0.24 per cubic meter². Given a tank size of 100,000 m³, waste disposal can add up to \$24,000 onto existing project costs. Though more modest sized containers would significantly reduce the cost for waste disposal, this expense still remains a major consideration in the efficacy of any given treatment.

Application of a Float Coat

A float coat is a corrosion inhibiting oil that is applied to a large volume system during a typical hydrotesting process. The float coat, being a hydrocarbon-based product, floats on the surface of the water allowing for a unique application using a much smaller volume of product than typical chemical additives.

The vessel floor and initial meter of wall height is sprayed with a layer of the float coat before any water is added to the system. Water is slowly added into the system, until a point just below the initial spray treatment, so to avoid disturbing the applied float coat protective coating. The remainder of the float coat is applied to the top of the water layer. Hydrotesting is then carried out as normal with care to fill the system at such a rate that the float coat layer on the water’s surface is not disturbed. As the hydrotest proceeds the walls of the vessel are coated with the float coat and further recoated as the vessel is drained.

EXPERIMENTAL PROCEDURE

Using a float coat has proven to be a viable preservation technique for ASTs and other large vessels during hydrotesting via a number of laboratory studies as well as real-life application.

Laboratory Testing: Humidity Testing

ASTM⁽¹⁾ D1735³ and ASTM⁽¹⁾ D1748⁴ conditions are standard accelerated weathering environments. Both of these environments were used to evaluate the corrosion resistance of the oil film in non-submerged situations such as the conditions experienced within an AST after a hydrotest and during preservation.

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ASTM⁽¹⁾ D-1735

ASTM⁽¹⁾ D-1735 is a test which examines a coating's resistance to constant water fog in a warm environment. The temperature of the chamber is held at 38 °C (100 °F), and deionized (DI) water is continuously fogged into this space such that 1.0-3.0 mL is collected on an 80 cm² surface area every hour. Steel panels are cleaned, coated with the float coat, and drained prior to being placed in the test chamber 15° from vertical. Significant corrosion is typically witnessed on control samples within one day, but the duration of testing is dependent on how long the test panels remain free of corrosion.

ASTM⁽¹⁾ D-1748

ASTM⁽¹⁾ D-1748 is a humidity test which examines a coating's resistance to high temperature and humidity. The temperature of the chamber is held at 48.9 ± 1.1 °C (120 ± 2 °F), and the panels are suspended by hangers designed to not allow water to drain from the hanger to the panel's surface. These hanging panels are then rotated through the chamber to allow every panel to experience identical conditions. Corrosion is typically witnessed on control samples within one hour, but the duration of testing is dependent on how long the test panels remain free of corrosion. This test was modified by using .063" x 2" x 4" SAE⁽²⁾ 1008 cold rolled steel panels and preparing the surface according to the procedure described in 8.2 – 8.3.6 without performing the heated solvent cleaning described in 8.3.7 – 9.2. Rather, the top edges of the panels were protected after removal from the solvent referenced in section 8.3.6 and the float coat was applied to the panel as described in section 9.2.

Laboratory Testing: Immersion Testing

Immersion testing was performed in a 3.5 wt% solution of NaCl in DI water. This solution was held in a cylindrical glass cell with a 5" height and a 2" diameter. 200 g of this solution was used in each test cell to ensure the full immersion of the tested steel panels (.063 x 1 x 3" SAE⁽²⁾ 1008 cold rolled steel). 10 g of preservative oil was added to each cell to build a substantially thick layer on the surface of the water. Pre-weighed steel panels were slowly lowered through the float coat into the test solution to ensure an even coating. These cells were placed into a 40 ± 2 °C oven for two weeks before being removed and left at ambient conditions (22 ± 2 °C) for 21 weeks. At this time the panels were removed, the oil residue was cleaned off with methanol, and oxides were cleaned from the surface via a 7.8 M HCl solution. The panels were examined for mass loss and rate of corrosion was calculated using the following formula from ASTM⁽¹⁾ G-31⁵ (equation 2, section 12.4):

$$\text{Corrosion Rate (mpy)} = \frac{3.45 \times 10^6 \times W}{A \times T \times D} \quad (1)$$

'W' represents the mass loss in grams, 'A' is the panel surface area in cm², 'T' is the duration of the test in hours, and 'D' is the metal density in grams per cubic centimeter (7.87 g/cm³ for SAE⁽²⁾ 1008 steel). The corrosion rate reduction was also calculated by comparing the control sample to the test samples with the following formula:

$$\text{Corrosion Rate Reduction} = \left(1 - \frac{R}{C}\right) \times 100\% \quad (2)$$

Where 'C' represents the corrosion rate of the control sample and 'R' is the corrosion rate of the test sample.

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Laboratory Testing: Coating Thickness and Dosing Estimation

Coating thickness and appropriate dosage were determined by constructing a vessel in which to simulate the float coating process. A 5-gallon container was fitted with a ball valve near its base to act as a drain while a rubber hose, guided to the base of the container via a 1" diameter PVC pipe, was used to siphon water from another 5-gallon container. 4" x 12" SAE⁽²⁾ 1008 steel panels were suspended in the center of the vessel to act as stationary steel surfaces would in actual application. The proper dosage was determined by considering the water surface area, monitoring the addition of oil until a consistent film formed on the water, and raising the water level to coat the suspended steel panels. When the coating applied evenly without breaking the oil surface as it was raised over the panel, the dosage was considered adequate for float coat application. After draining the water from the vessel and allowing excess oil to drip from the test panel's surface, the film thickness was evaluated with a standard wet film thickness gauge.

Real World Analysis

Float coating has been successfully used as an AST preservation method in the Middle East. This project provided affordable corrosion protection through the application of a float coat while hydrotesting the system. The float coat was applied with neither minimal disruption to normal application procedures nor any negative impact on any cured phenolic epoxy liners, typically used in tanks.

A water sample from the float coat system was submitted to a third party chemical analysis firm for chemical testing. Analysis for several hazardous chemicals was performed, including dissolved metals, such as lead, mercury, and zinc, and several hazardous hydrocarbons, such as benzene, toluene, naphthalene, and others. Tests were carried out according to APHA⁽³⁾ 3120 B⁶, US EPA⁽⁴⁾ SW 846/8260B⁷, and US EPA⁽⁴⁾ SW 846/8081B⁸ for various metals, volatile organic compounds, and organochlorine pesticides, respectively. Upon gaining disposal approval, hydrotest water was disposed of with minimal impact to normal operational procedures.

RESULTS

Laboratory Testing: Humidity Testing

ASTM⁽²¹⁾ D-1735

Product A was tested according to ASTM⁽¹⁾ D-1735 to assess its corrosion protection capabilities where constant water fog is present. Treated 3" x 5" SAE⁽²⁾ 1008 steel panels were tested for 500 hours in the specified conditions before any corrosion was seen, pictured below in Figure 1. In contrast, a control steel panel, showed signs of corrosion within 24 hours.

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Figure 1: ASTM⁽¹⁾ D-1735 test results with Product A. The control panel is pictured on the far left.

ASTM⁽¹⁾ D-1748

Product A was tested according to ASTM⁽¹⁾ D-1748 (with modifications noted above) to assess its corrosion protection in a constant condensing humidity environment. Treated steel panels were tested for over 1950 hours in the specified conditions before any corrosion was seen, pictured below in Figure 2. In contrast, a control steel panel showed signs of corrosion within 24 hours.



Figure 2: ASTM⁽¹⁾ D-1748 test results with Product A. The control panel is pictured on the far left.

Laboratory Testing: Immersion Testing

Product A was tested in immersion conditions as noted above to assess the level of protection offered in a corrosive solution. As shown below in Table 1, each panel that was treated with Product A witnessed a corrosion rate reduction over 98%.

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**Table 1
Immersion Test Results**

Sample	Treatment	Starting Mass (g)	Ending Mass (g)	Mass Loss (g)	Corrosion Rate (mpy)	Corrosion Reduction
1	Product A	23.8277	23.8234	0.0043	0.012	98.3%
2		23.8607	23.8567	0.0040	0.011	98.5%
3		23.8432	23.8381	0.0051	0.014	98.1%
4	Control	23.9134	23.6430	0.2704	0.73	N/A

Laboratory Testing: Coating Thickness and Dosing Estimation

Immediately after application of Product A, a wet film thickness gauge indicated a 175 micron (7 mils) film thickness on the surface of the test panel. After being allowed to drain for one hour, the film was reevaluated to find a wet film thickness of less than 25 microns (1 mil).

Through several trials the necessary amount of product required to ensure a uniform coating thickness upon application, was determined to be 5.5 liters of Product A per square meter of cross sectional tank area. In the case of tanks with a non-constant cross sectional area (e.g. frustum-shaped tanks), the average cross sectional area should be used. Through similar trials the required amount of product to properly coat vessel walls was determined to be 1 liter per 20 square meters. The test apparatus is shown below in Figure 3 and Figure 4.



Figure 3: Image of the inside of the float coating test vessel. The vessel can accommodate several standard 4" x 12" test panels (3" x 5" test panels pictured above).



Figure 4: Total view of the float coating test vessel. Test panel holder, funnel and tubing for bottom-up filling of the vessel, and drain spout can be seen.

Real World Analysis

Select results from the elemental analysis testing of water used to apply Product A are provided below in Table 2.

**Table 2
Select Results from Hazardous Chemical Testing⁹**

Chemical	Practical Quantification Limit (PQL)	Units	Result
Arsenic	0.09	mg/L	N/D
Cadmium	0.15	mg/L	N/D
Chromium	0.1	mg/L	N/D
Lead	0.08	mg/L	N/D
Zinc	0.51	mg/L	N/D
Mercury	0.0005	mg/L	N/D
1,1-dichloroethene	6	µg/L	N/D
Chloroform	5	µg/L	N/D
Benzene	4	µg/L	N/D
Toluene	5	µg/L	N/D
Chlorobenzene	6	µg/L	N/D
Styrene	5	µg/L	N/D
Naphthalene	9	µg/L	N/D
4,4'-DDT	0.16	µg/L	N/D
Endrin	0.38	µg/L	N/D

**N/D = Not Detected*

CONCLUSIONS

Traditional chemical treatment and epoxy coatings can be both expensive and time consuming methods for protection and preservation of large vessels. In large volume systems, a float coat can offer a more economical corrosion protection solution than traditional chemical treatment by offering dosage rates based on surface area compared to costly dosage rates based on volume. Additionally, the minimally-invasive application method can offer significant time savings when compared to traditional coating applications.

Humidity testing according to ASTM⁽¹⁾ D-1735 and D-1748, and immersion testing based on ASTM⁽¹⁾ G-31 show excellent corrosion protection from the thin film left by Product A. Field application of the float coat product demonstrates the efficacy of these points. As shown in table 2, this treatment does not impact the chemistry of the hydrotest water allowing for water disposal to be carried out with only minimal disruption to normal disposal procedures, providing time and cost savings by significantly reducing or eliminating the expensive and lengthy process of handling large volumes of industrial waste.

The use of a float coat is an affordable and effective method for corrosion protection of large volume vessels. Cost savings, time savings, and environmental considerations provide the basis for this novel treatment to vie with traditional preservation methods.

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