BATTERIES THAT KEEP GOING AND GOING AND GOING…

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ABSTRACT
Tank lining failures are not an uncommon occurrence in the oilfield. Sometimes we chalk it up to bad luck, poor application, lying paint salesmen or just bad coating. But isn't there some science and testing behind tank lining formulations? This paper will describe some of the testing procedures for qualifying tank linings and the science behind them. There will also be some discussion about how failures seen in the lab correlate to failures in the field.

Key words: coatings, tank linings, epoxy, autoclave, atlas cell, cold wall effect, cathodic disbondment

INTRODUCTION

In boom time or bust, tank linings are a vital part of any Operators' plan to protect steel tanks from corrosive fluids. With an estimated 100,000 API 12F tanks currently in service in Texas, understanding the dynamics that cause tank linings to perform (or not) is more complicated than it may seem. When it comes to surface equipment specifications, we assume that the 140°F design temperature of a heater treater is the worst case scenario for a tank lining. When in fact, its quite possible and probable that a pumper may increase the heater treater temperature to 160°F or even 180°F to increase pressure to the sale line. This higher temperature fluid is then stored in a tank designed for a max temperature of 120°F. It's not until the coating has failed, the shell or floor has a perforation caused by rampant corrosion and the secondary containment is full of oil that we realize something has gone terribly wrong.

Historically, many tank linings have been chosen based on the premise that the only fluid constituents that we should protect against are crude oil and saltwater. This author has seen linings fail within months if temperature, pressure, ph and acid gases aren't accounted for. This paper will describe several test methods and some of the reasons they are employed to determine field performance of tank linings.

EXPERIMENTAL PROCEDURE

Samples of 5 high build 100% solids high performance epoxies were prepared by the coating manufacturer. Three of the samples were epoxy novolac and the remaining two samples were immersion grade epoxies. Each lining material was applied in a single coat to carbon steel panels that had been abrasive blasted to an SSPC-SP5/ NACE No. 2 Near White Metal Blast[1] with a 2.0 to 3.0 mil angular profile. The wet film thickness of each material was targeted at 20 mils. Due to the 100% solids formulations of each material, the dry film thickness (DFT) was 20 mils as well.

In an effort to test the coatings against aggressive conditions found in the field, the coatings samples were subjected to Atlas Cell and Pressurized Atlas Cell testing using NACE Standard TM0174-2002[2] modified.

The premise of the Atlas Cell, is to test the coating samples under atmospheric pressure, high internal fluid temperatures (typically to match formation fluid temperatures at the surface) and cooler external steel temperatures. A good example of this, is a production storage tank filled with 120°F produced water while the steel temperature is 90°F due to cooler atmospheric temperatures. The purpose of inducing this thermal gradient is to produce the "cold wall effect[3]". The Cold Wall Effect is known for causing coatings to blister and is produced when the steel substrate is colder than the coatings' surface while immersed in water. Steel tends to be good heat conductor, while most immersion coatings would be considered insulators of heat. It is well known that no organic coating is impermeable to water so even the best immersion grade epoxies allow some penetration of water molecules (see figure 1). Therefore, if the coating is exposed to water or water vapor, the water molecules will start moving into the coating. As the warm water molecules begin moving through the warm coating they meet the colder steel substrate and begin to condense. As the water molecules condense on the steel surface, it builds pressure in between the coating and the substrate. This pressure exceeds the adhesive power of the coating and a water containing blister will form (see figure 2).

Due to the construction of the Atlas Cell, it is possible to test the samples with liquid hydrocarbons, water (distilled or brine) and water vapor. In this test, the cell was filled with the following:

Hydrocarbon Phase - 1:1 Kerosene / Toluene
Aqueous Phase - 15% NaCl in Distilled Water
Vapor Phase - Vapor
Test Pressure - N/A
Test Temperature Internal - 120°F
Test Temperature External - 90°F
Duration - 6 months

The second test method is similar to the Atlas Cell described above except that the test apparatus is able to handle pressure, hence the name, Pressurized Atlas Cell. This test is typically performed for 30 days to six months in an effort to test coatings for pressure vessel service. This test also recreates the Cold Wall Effect as the coated panels are exposed to a negative thermal gradient, sometimes as high as 60°F. In this test, the apparatus was filled with the following:

Hydrocarbon Phase - 1:1 Kerosene / Toluene
Aqueous Phase - 1% NaCl in Distilled Water
Vapor Phase - 5% H_2S, 5% CO_2, 90% CH_4
Test Pressure - 1.38 MPa / 200psi
Test Temperature Internal - 140°F
Test Temperature Atmospheric - 70°F
Duration - 30 days

CONCLUSION

The result of The Cold Wall Effect as well as pressure, hydrocarbons, acid gases and liquid and vapor water were investigated. The outcome was evaluated, and it was found that high performance novolac epoxies performed far better than standard immersion grade epoxies overall.

The Atlas Cell Test showed that standard immersion grade epoxies failed within the first month of testing. It is determined that standard immersion grade epoxies are not suitable for environments where a thermal gradient and acid gases can be expected unless prior testing has been done. One of the high performance novolac epoxies performed flawlessly throughout the entire 6 month test.

The Pressurized Atlas Cell Test showed that standard immersion grade epoxies failed during testing, exhibiting large blisters in the vapor and aqueous phase (see figure 3). It is determined that standard immersion grade epoxies are not suitable for environments where a thermal gradient and pressure can be expected unless prior testing has been done. All of the high performance novolac epoxies performed flawlessly throughout the entire 30 day test (see image 4).

REFERENCES

1. NACE No. 2/SSPC-SP 10 Near White Metal Blast Cleaning

2. NACE TM0174-2002 Laboratory Methods for the Evaluation of Protective Coatings and Linings Materials on Metallic Substrates in Immersion Service
3. Hempel, The Cold Wall Effect - Former TRB Article I-7

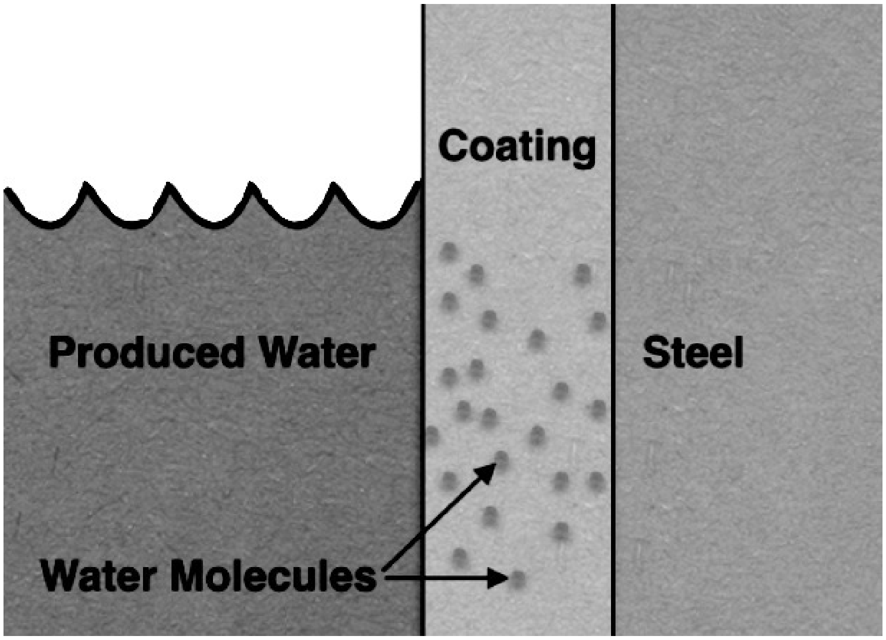

FIGURE 1

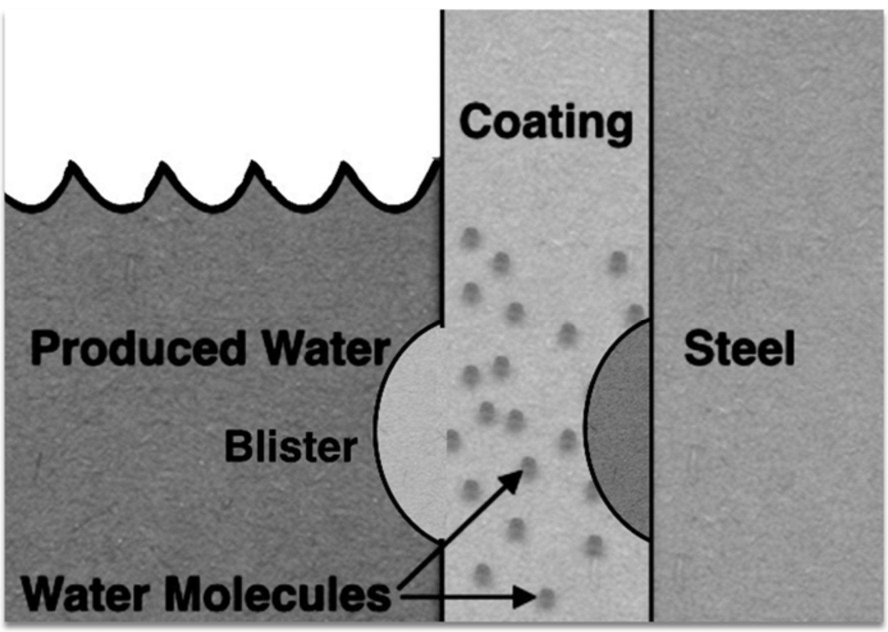

FIGURE 2

FIGURE 3

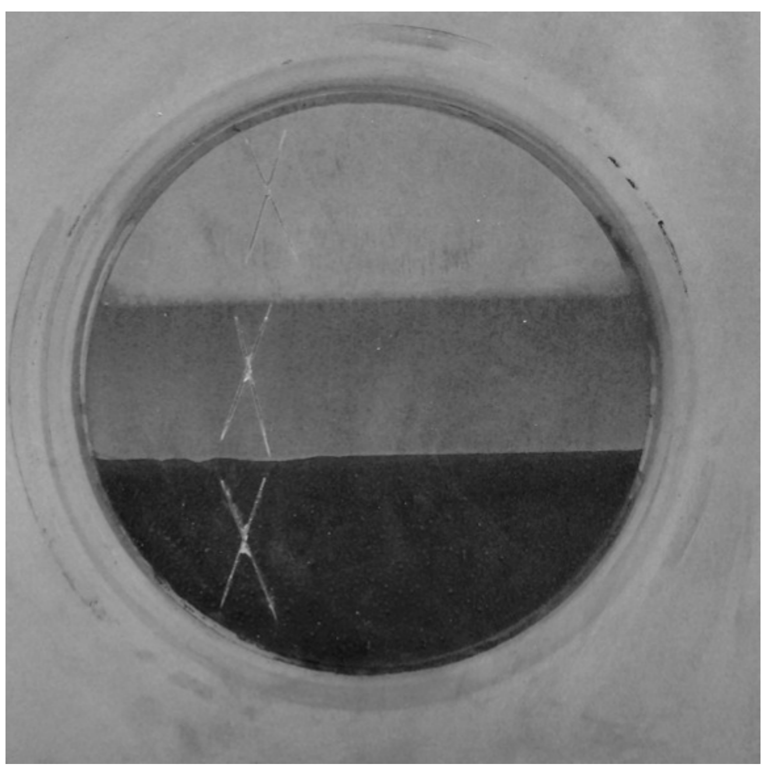

FIGURE 4