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Use of Corrosion Inhibitors for Control of Corrosion in Double Bottom AST's.

Introduction

Double bottom tank installations, and tanks with HDPE liner containment, often create unique corrosion control challenges. Current from external cathodic protection (CP) systems will not flow through the lower floor of a double bottom tank, or a HDPE containment liner. Therefore, cathodic protection is only applied by installing anodes between the upper floor and lower floor, or containment liner. Many years of experience has proven that control of corrosion, by cathodic protection, of tank bottoms that are separated by a distance of less than about 10 to 12 inches is problematical. Cathodic protection systems are also nearly impossible to maintain, install or replace on a retrofit basis once this type of tank is in service.

Research and fieldwork indicates that corrosion control can be achieved using **Vapor Corrosion Inhibitors** (VpCI) within double bottom or lined containment environments. Rials & Kiefer of Conoco Oil published a technical paper (S.R. Rials and J.H. Kiefer, "Evaluation of Corrosion Prevention Methods for Aboveground Storage Tank Bottoms", Materials Performance, NACE, January 1993) presenting results from testing a variety of corrosion control options for double bottom tanks. One of the tests included a vapor corrosion inhibitor mixed with a typical tank pad material. Corrosion was monitored and measured over an extended time period. Almost no corrosion developed in the presence of the VpCI.

Real world experience utilizing VpCI's for void space corrosion control over a 15-year time span has confirmed the longevity of this approach. Corrosion inhibitors are effective alone, or in combination with CP. Inhibitors have a long history of corrosion protection under numerous types of conditions (wet, corrosive environments and void spaces).

Corrosion Mitigation with Corrosion Inhibitors

Corrosion Inhibitor Basics

Vapor corrosion inhibitors have been used for many years to solve the basic corrosion control problem for metal surfaces in a confined space. VpCI's are a sub-class of metal inhibitors. Inhibitors have been used by the oil and chemical industry for over 50 years, minimizing difficult corrosion problems. A unique characteristic of VpCI is its relatively high vapor pressure (.0001 mm Hg). These inhibitors volatilize at room temperature, re-depositing on metallic (as well as other) surfaces in an equilibrium condition in confined spaces. The inhibitor then works as any other inhibitor, stopping or retarding the corrosion mechanism. They are chem-adsorbed in a

monomolecular thick layer. Some compounds are specific for ferrous metals while others are effective on both ferrous and non-ferrous metals.
See attachment "Volatile Corrosion Inhibitors" for more detailed information.

Volatile Corrosion Inhibitors

In the last 20 years Cortec Corporation has investigated these compounds and developed a series of low toxicity inhibitors (1), many being in the range of table salt, 2000 to 3000-mg/Kg oral LD-50. A key characteristic of these materials is that they protect against corrosion in the presence of water vapor, chlorides, hydrogen sulfide, sulfur dioxide, nitrogen oxides, and other compounds found in a corrosive industrial environment.

VpCI's are being used daily for successful corrosion control. They are produced and used in many forms: pure VCI powder, VCI liquids, "emitters" used in electrical and electronic applications, VCI plastic films and paper used in packaging, lubricating oil/VCI combinations, and incorporated into standard solvent and water based paint formulations. Companies such as DuPont, Conoco Oil, IBM, Motorola, General Motors, Ford, Chrysler, and Volkswagen have incorporated these materials into their standard specifications. Organizations such as the United States Navy & Air Force use this type of protection, saving vast amounts of money compared to conventional preservation methods.

Techniques for Measuring VpCI Effectiveness and Corrosion Mitigation

Corrosion Rate Probes.
An electrical resistance (ER) corrosion rate probe provides a real-time calculated corrosion rate measurement described in mils per year metal loss. These probes can be installed at numerous locations under a tank floor to evaluate the corrosion rate of the interstitial space environment, and thus the effectiveness of corrosion inhibitors.
The corrosion rate probes PSI would utilize are supplied by Metal Samples Corrosion Monitoring Systems. They are installed through the open end of PVC casing that PSI would install in the interstitial space, or directly through the tank shell and into the sand. Information is attached on the ER probes in general, the two probes that PSI would utilize for the AST's, and the meter used to acquire data for corrosion rate analysis.

ER Probe Information

ER 0500 Probe

ER 3100 Probe

Meter

Program to Mitigate and Monitor Corrosion in the Interstitial Space of a Double Bottom Aboveground Storage Tank.

Summary Description

The Praxair Services, Inc. program designed to control the corrosion of the upper tank floor within a double bottom tank includes the following components:

1. Complete initial tasks one month prior to installation of corrosion inhibitor.
   - 1.1. Inoculate the tank with the tracer chemical and complete a tracer chemical integrity test of the upper floor.
   - 1.2. Install PVC casing and corrosion rate probes in the interstitial space to establish the corrosion rate at each of the probes.
   - 1.3. Install necessary access ports on the tank shell into the interstice between the upper and lower floors.
   - 1.4. Seal any gaps or open areas between the underside of the upper floor and the tank shell.

2. Inhibitor installation.
   - 2.1. Deliver a vapor corrosion inhibitor as a slurry into the interstitial space in such a way that the VpCI is evenly and effectively distributed throughout the space.
     Cortec VpCI #609 is the corrosion inhibitor best suited for this AST application. A product sheet from Cortec follows:

     VpCI 609 Product Sheet
   - 2.2. Monitor the corrosion rate probes for a reduction in the corrosion rate after the inhibitor contacts the probes.

3. Inhibitor effectiveness monitoring.
   - 3.1. Monitor the corrosion rate of the environment to establish the initial effectiveness of the inhibitor.
   - 3.2. Monitor and record the corrosion rate bi-monthly to verify that the inhibitor is continuing to be active and effective.
4. Annual testing.
   - 4.1. Perform a tracer chemical test of the upper tank floor integrity to provide assurance that the upper floor does not leak and that the inhibitor is controlling corrosion.
   - 4.2. Record the corrosion rate data and perform any necessary maintenance / testing of the probes.

5. Replenish the inhibitor after a few years whenever the corrosion rate probes indicate that the effectiveness of the inhibitor has significantly diminished.

Installation of PVC Casing & Corrosion Rate Probes into the Interstitial Space.

1"–1 ¼" PVC casing will be installed with vacuum equipment. The casing will be installed open-ended so that the ER corrosion rate probes can be installed into the sand at the end of each casing. The casing and corrosion rate probes will be installed approximately one-month prior to the installation of the corrosion inhibitor. That period of time will allow the probes to normalize and produce accurate corrosion rate data prior to the installation of the corrosion inhibitor. A preliminary design for placement of the casing and probes under a 100' diameter tank follows.

100' AST Probe Plan View

Sealing the Interstitial Space.

It is necessary to seal the interstice between the two floors in order to retain the inhibitor slurry and prevent intrusion of fresh water. Typically, there are gaps between the shell and the underside of the upper floor. PSI will utilize a special procedure and caulking materials to accomplish a watertight seal.

Process for Delivery of Vapor Corrosion Inhibitors into the Interstitial Space of In-service Double Bottom Tanks.

Delivery of VpCI in Interstitial Space

This process requires that the VpCI be mixed as a 5% solution with water to form a slurry. The slurry is then pumped into the interstitial space. This would be accomplished as follows:

- Pump the slurry under low pressure into the space through multiple ports and allow time for the slurry to migrate throughout the space.
- Monitor other ports around the tank shell for indication of the slurry exiting the interstitial space.
- Monitor the corrosion rate probes for indication that the slurry has reached them.
- Stop flow once the specified quantity of slurry has been pumped into the space and the corrosion rate data indicates complete coverage.
- Close all ports.

Monitoring of the Corrosion Rate.

Once the inhibitor has been effectively delivered throughout the interstitial space, the ER corrosion rate probes data will produce a reduced "mils per year" corrosion rate from each probe area. This data will be recorded, then compared to future corrosion rate data from each probe. It will be necessary to measure the corrosion rate periodically to ensure corrosion mitigation is continuing to occur.

The frequency of corrosion rate measurements is not defined in any standard. Factors influencing the frequency are regulatory requirements, experience with each tank, etc. Initially, bi-monthly measurements would be appropriate. The measurements can be obtained by on-site personnel or PSI personnel.

Tracer Chemical Integrity Test.

The tracer chemical integrity test of an AST is accomplished by mixing a very small quantity (2-5 parts per million) of a specific tracer chemical with the product contained in an AST, then extracting samples of the air in the soil below the tank floor. The air samples are extracted through the ports and any PVC casing previously installed in the interstitial space. The samples are injected into containers, then sent to our laboratory and analyzed for the presence of the tracer chemical. If tracer is identified in the air sample then an active leak in the tank is indicated. This integrity test will identify active leaks with flow rates as low as 1 gallon per day.

An initial tracer chemical tank floor integrity test is beneficial to establish that prior to the introduction of the corrosion inhibitor, the tank floor does not have any corrosion pits causing active product loss. An annual tracer chemical integrity test would then be utilized to verify that the corrosion inhibitor is effective and there are no new corrosion pits causing active product loss.

Replenishment of the Inhibitor.

The expected effective life of the initial corrosion inhibitor installation varies according to the following factors:

- Quantity and frequency of water intrusion into the interstitial space.
- Effectiveness of inhibitor delivery and distribution.
- Quantity of inhibitor successfully distributed throughout the space.

When data from the corrosion rate probes indicates that the corrosion rate is increasing and the inhibitor needs to be replenished, then the initial delivery method would be used again.

Preliminary Pricing

PSI is presently developing pricing for this service. At this time, we need to evaluate each project before providing firm pricing. Factors influencing the pricing include:

- The number and length of PVC casings to be installed into the interstitial space.
- The number of ER corrosion rate probes to be installed.
- The method of corrosion inhibitor delivery into the space.
- The quantity of corrosion inhibitor to be installed.
- The utilization of a tracer chemical integrity test.

A rough cost estimate for a 100’ diameter tank is $25,000 to $35,000. PSI is prepared, and would appreciate, the opportunity to develop a firm estimate on specific tanks.