Mitigation of Soil-Side Corrosion on Double-Contained Aboveground Storage Tank Floors

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The application of vapor phase corrosion inhibitor (VCI) chemistry, combined with a corrosion rate monitoring system, provides an excellent method to mitigate and monitor corrosion within the interstitial spaces of aboveground storage tank bottoms. This article describes VCI chemistry and presents several case histories of VCI usage in these spaces.

Double-bottom tank installations and tanks with high-density polyethylene (HDPE) liner containment often create difficult 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. CP can be applied only by installing anodes between the upper floor and lower floor, or containment liner.

Many tanks have been upgraded with double bottoms, or under-tank liners (Figure 1), and a variety of CP systems have been installed on these tanks. Some interstitial space CP systems have become ineffective, however. Replacement without taking the tanks out of service and removing the floors is not practical or economical. Operating the tanks without soil-side corrosion control on the fluid containment floor is not an acceptable option for many tank owners and regulatory authorities.

Corrosion Control with VCIs

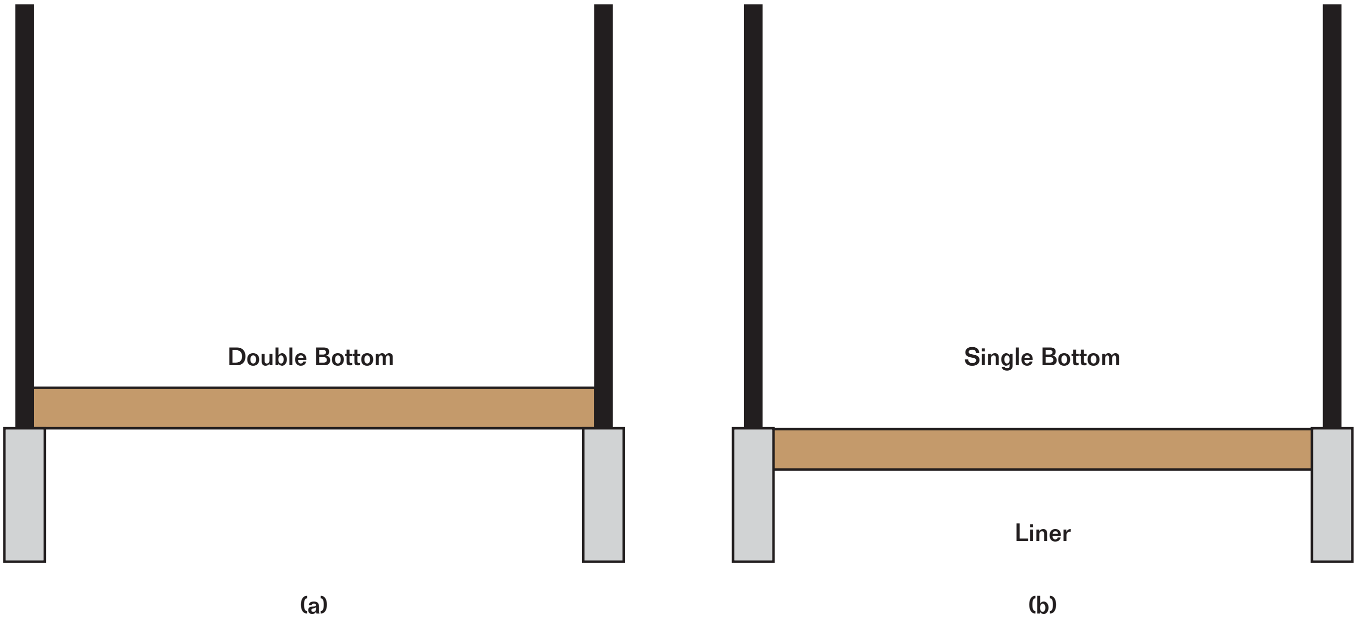
Engineered systems utilizing vapor phase corrosion inhibitor (VCI) technology offer an important alternative for mitigation of tank floor corrosion. These systems are economical, effective, and can be installed on a retrofit basis without disrupting tank service.

A developing history of corrosion rate data provides confidence that if the VCI chemistry is effectively delivered under the tank bottoms, and if the intrusion of fresh air and water under the tanks is eliminated, soil-side floor plate corrosion will be mitigated. VCIs are effective alone, or in combination with CP.

Fundamentals of VCI Operation

It is important to recognize that VCI chemistry/technology is very mature and well proven. The author's company has researched, invented, innovated, manufactured, and applied environmentally friendly VCI chemistry for over 30 years to solve

FIGURE 1



Tank configurations having interstitial spaces: double bottom and (b) HDPE liner under a single bottom.

many basic corrosion control challenges on metallic surfaces. VCI solutions for corrosion mitigation are utilized by many major corporations in most regions of the world for a wide variety of applications.

Amine carboxylate-based VCIs are used beneath aboveground storage tanks (ASTs). These environmentally friendly products are effective for prevention of metal corrosion in three phases: on the surface of the steel in contact with the sand tank pad materials, at the air/sand interface, and in the vapor space above the sand. When a VCI output is released within an AST interstitial space, protective vapors disseminate until equilibrium, determined by the partial vapor pressure, is reached. The mechanism for corrosion control is the formation of a monomolecular layer throughout the soil-side surface of the tank floor. VCI molecules adsorb on the steel surface to suppress both metal dissolution and the reduction reaction (both the anodic and cathodic processes). This adsorption is accomplished without the need for direct contact of the VCI chemical on the metal surface.

FIGURE 2

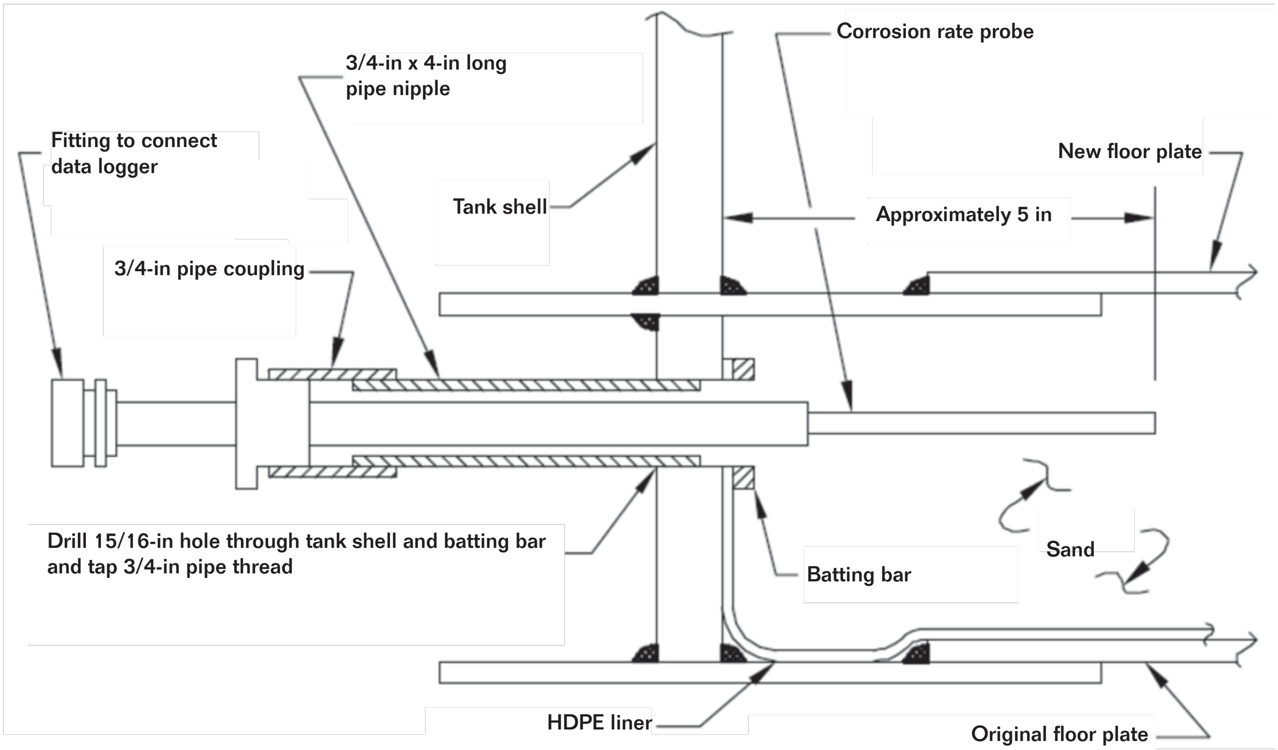
Corrosion rate monitoring probe: (a) delivering VCI slurry under the tank floor and (b) completed ER probe assembly through the ringwall.

U.S. History with VCIs in ASTs

In 1993, Rials & Kiefer[1] published a technical paper presenting results from testing a variety of corrosion control options for double-bottom tanks. One of the corrosion prevention methods tested included a VCI 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 VCI.

One of the first known AST applications of the VCI technology in the United States was in Florida. A VCI was installed in a water slurry mixture under 17 ASTs in Florida between the years of 2000 and 2001. Electrical resistance (ER) corrosion rate probes were installed under each tank to monitor the inhibitor effectiveness. Approximately five years after VCI application, the corrosion rate probe data were evaluated. The corrosion rates were still very low, ranging

FIGURE 3



ER corrosion rate probe installation through the tank wall in a double-bottom tank.

from 0.150 to 0.720 mils (3.8 to 18 μm) metal loss per year.[2]

The author spent about 10 years engineering and developing systems and processes for delivery of VCI chemistry under ASTs. He applied this solution to well over 100 tanks in the United States.

Today it is estimated that more than 10 major oil and gas companies operating ASTs in the United States utilize VCI chemistry to control corrosion on tank floors. VCIs are also soon to be used in the Middle East for mitigation of AST corrosion challenges that are unique to the Persian Gulf region.

Monitoring and Mitigation of Corrosion in the Interstitial Space

The Cortec VCI system for ASTs is named CorroLogic†. A typical system includes:

1. Sealing any gaps between the tank floor and dead shell on double-bottom tanks, or gaps between the tank floor and concrete ringwall on single-bottom tanks to prevent intrusion of fresh water and air into the interstitial spaces of these tank systems.
2. Engineered application of the VCI into the interstitial space in such a way that effective distribution of the chemistry is ensured.
3. A corrosion rate monitoring system utilizing electrical resistance probe technology to measure the real-time rate of corrosion within the interstitial space and near the tank floor.

Sealing the Interstitial Space

Significant mitigation of interstitial space corrosion can be accomplished by preventing intrusion of fresh water and fresh air into the space. On double-bottom tanks there are gaps between the underside of the upper floor and the dead shell. Those gaps can be welded or sealed with a caulk/tape system. On single-bottom tanks with liners, consideration should be given to sealing the chime plate to ringwall interface with a caulk and tape system.

Application of the VCI

For new construction tanks, the inhibitor is applied in a powder form on top of the liner before the sand is installed. The powder is contained in long strips of breathable EcoPouches†. This system is easily installed by the tank-erecting contractor.

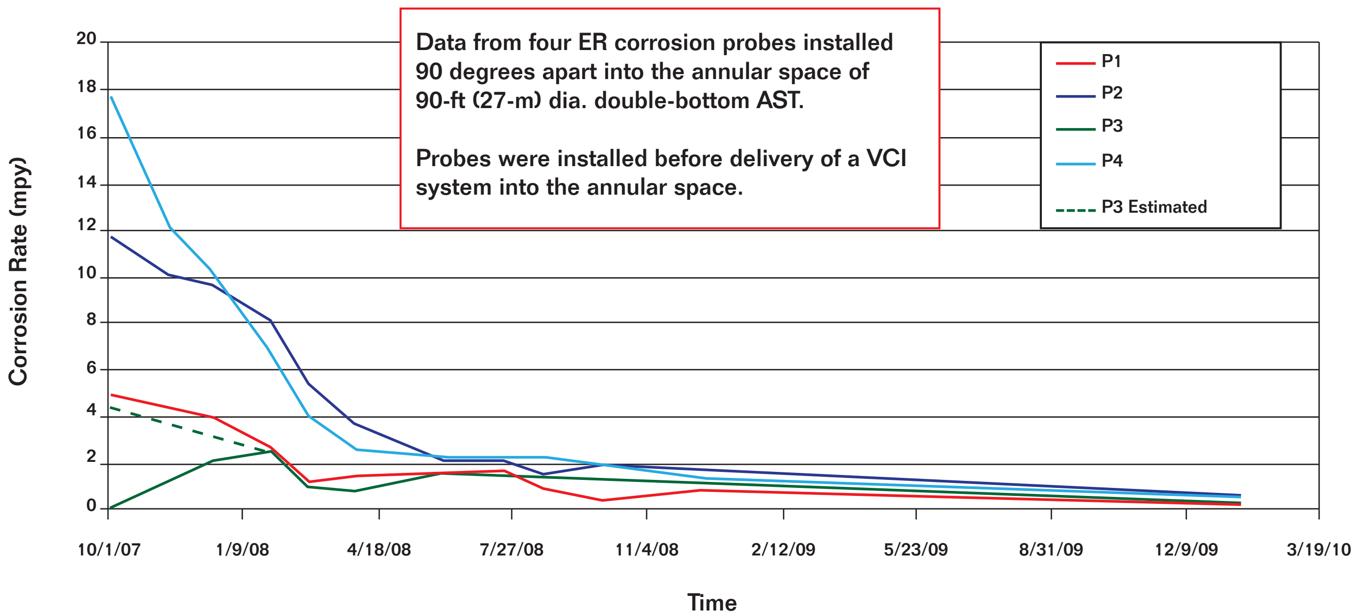
For in-service double-contained tanks, the VCI is applied into the interstitial space by delivery of concentrated inhibitor slurry beneath the liquid bearing floor. The slurry injection is accomplished through a network of perforated pipes that is installed into the space with vacuum equipment. Special mixing equipment and delivery systems are used to apply the slurry through the injection pipes.

Corrosion Rate Monitoring System

ER corrosion rate probes (Figure 3) are installed to obtain real-time corro-

†Trade name.

FIGURE 4



ER probe data from an AST over a period of about 2½ years.

sion rate measurements of the interstitial space environment. The data obtained from the probes are the calculated mils per year metal loss. The ER probes are installed at numerous locations under a tank floor. In double-floor tanks they are installed directly through the dead shell and into the sand a few inches beyond the shell. In single-bottom tanks with liners they are installed through the ringwall and into the sand. In either case, if ER probe data are desired further under the tank, the probes can be installed through access pipes retrofitted into the space.

Some operators choose to install the corrosion rate monitoring systems before any inhibitor is applied in order to assess the corrosiveness of each AST interstitial space. Once a VCI system is installed, the corrosion rate monitoring system provides continuous evaluation of the corrosion inhibitor effectiveness for the life of the tank.

Figure 4 shows typical ER probe tank data that illustrate the performance of VCI systems over nearly 2½ years.

System Maintenance

A significant advantage associated with this type of corrosion mitigation system is reduced maintenance costs. There are no ongoing maintenance requirements, other than collecting the corrosion monitoring system data on a predetermined schedule. There are no power costs, no wiring to repair, and no equipment to maintain. If the corrosion rates increase sometime in the future to higher than desired levels, the inhibitor can be replenished.

Conclusions

When steel is exposed to properly applied VCI chemistry, the corrosion is reliably mitigated. This has been proven in a wide variety of applications for many years throughout the world. The use of environmentally friendly VCI chemistry and engineered systems for aboveground tanks is maturing and expanding. Application of VCI chemistry, combined with real-time corrosion rate monitoring, provides AST owner/operators with an effective and economical solution to the challenge of soil-side corrosion mitigation on double-contained ASTs.

References

1. S.R. Rials, J.H. Kiefer, "Evaluation of Corrosion Prevention Methods for Aboveground Storage Tank Bottoms," *MP* 32, 1 (1993).

2. T. Whited, "Inhibiting Tank Corrosion," *Hydrocarbon Engineering* 8 (2005).

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