From Spent Anodes to Lower Spending: Introducing VCIs for Tank Bottom Protection in Malaysia

What happens when the cathodic protection (CP) anodes under an aboveground storage tank (AST) bottom are fully depleted after 30 years? The simple answer is that protection must be renewed to maintain tank floor integrity and meet standards for mitigating soil-side corrosion. However, that does not mean that protection must be done the same way it always has been done.

This was the crossroads a major chemical manufacturing plant in Malaysia was facing in 2018. One of its firewater storage tanks had been protected with pre-packaged magnesium anodes designed to preferentially corrode instead of the tank bottom. Once these anodes were fully depleted, the tank bottom had no line of defense. A further challenge was that, since the tank was already in place and did not have much space beneath it, the cost of replacing anodes was much higher than for new tank protection, with a greater risk of damaging the tank bottom.

CorrTrol, a corrosion engineering services company hired by the chemical manufacturing facility to do a feasibility study and provide recommendations, came to this conclusion and suggested applying vapor corrosion inhibitors (VCIs), a technology that was new to the client but has been undergoing field trial for the last three decades and had recently found a place in API and AMPP standards. This method, which was more cost-effective and did not require the tank to be emptied or raised, captured the client's attention, and it enlisted CorrTrol to conduct the first project of its kind in Malaysia, joining the growing trend of enhancing AST bottom protection with VCIs.

History of VCIs for ASTs

One of the earliest mentions of using VCIs for storage tank bottoms was in a technical paper published by *Materials Performance* in January 1993. Written by S.R. Rials and J.H. Kiefer of Conoco Oil, it included a VCI test that resulted in barely any corrosion.[1] Additional testing and reporting followed with positive results, indicating that VCI could reduce corrosion and in some cases be used in conjunction with CP.[2–4]

Among the most recent data are the results of a VCI test at the Cushing crude-oil terminal from 2014 to 2019. At the five-year inspection, corrosion indications and average metal loss suggested a significant drop in corrosion rates and confirmed that VCI and CP could have beneficial results when used together.[5]

Going hand in hand with promising results in the field, VCI has been officially enshrined in two industry standards for AST protection in the last five years. In 2021, the first edition of API Technical Report 655 was released on the topic of "Vapor Corrosion Inhibitors for Storage Tanks."[6] Two years later, AMPP published AMPP SP212474-2023, which included a section on the use of VCIs for protecting storage tank bottoms.[7]

Application of VCIs for AST bottom protection has mainly occurred in the United States and the Middle East—especially the latter with its major oil production activities in an extremely corrosive environment. The spread of VCI for ASTs in Malaysia marks another significant milestone in delivering this technology to tank farms in harsh regions that need it the most.

How VCI Works to Protect ASTs

VCIs are extremely well-suited to protecting voids below ASTs and have many advantages. Because the space under tank bottoms is enclosed and difficult to reach, monitoring tank floor condition and applying corrosion protection are challenging. Fortunately, VCIs are extremely adaptable because of their vapor-phase action. As a powder or a slurry, VCIs can be injected under the AST floor even after it is in use. These corrosion inhibitors vaporize and diffuse throughout the enclosed space until they reach equilibrium. VCIs are attracted to metal surfaces where they adsorb, creating a protective layer that interferes with the normal corrosive electrochemical reaction of oxygen + metal + an electrolyte. This VCI molecular layer significantly slows down the corrosion process, as seen in reduced corrosion rates.

Before drilling through the concrete to create openings for VCI injection and ER probes, workers scanned the concrete ring wall to locate and avoid embedded reinforcing metal. Image courtesy of CorrTrol.

VCI Advantages for AST Protection

Because of their diffusive action, VCIs have the potential to access difficult-to-reach pockets underneath the tank bottom where the metal floor may not be in direct contact with the sand pad. This can be a serious issue for impressed current cathodic protection (ICCP), the most common form of tank bottom protection. ICCP sends an electric current through the sand pad to counteract the natural flow of electrons from the anode to the cathode of a corrosion cell. Portions of the tank not in contact with the sand pad current are therefore more vulnerable to corrosion.

Fortunately, VCIs can make up for this inconsistency either alone or in conjunction with CP by depositing a protective layer on metal surfaces within these pockets. It has even been suggested that the use of VCIs may reduce the amount of current needed for ICCP, allowing corrosion protection to be more efficient.[8]

Another advantage of VCIs is that they are much easier to apply than both ICCP and galvanic anode CP once the tank is constructed and in use. As mentioned in the case of the Malaysian firewater tank, costly equipment could have been required to insert the anodes, while the low clearance under the bottom plate would have increased the risk of damaging the tank when forcing anodes into place at multiple locations. In contrast, VCIs can be applied through a variety of avenues:

1) **Filled tank:** Drill through the ring wall and inject VCIs under the tank.
2) **Tank emptied for inspection:** Drill tiny holes in the tank floor, inject VCIs, and seal the holes.
3) **Tank undergoing inspection and floor replacement:** Inject VCIs through openings where new sections of floor are being installed.

These options make VCI application significantly more convenient and adaptable to different tank scenarios.

Case History: Malaysian Firewater Tank VCI Application

When choosing the VCI route for AST protection, it is important to select a contractor that has the knowledge and expertise to do the job. CorrTrol, the group that performed corrosion mitigation on the chemical manufacturing plant firewater tank, was an excellent candidate with its long history of working with CP (both ICCP and sacrificial anode CP) and providing other engineering services in the oil and gas industry.[9]

Injecting VCI. Image courtesy of CorrTrol.

Along with subcontractors for concrete coring and sand lancing, CorrTrol completed the work over a three-month period, facing special challenges such as a cracking ring wall, potential delays from rain and wet sand, special sand disposal procedures, safety concerns from handling a high-pressure compressor, and potential paperwork (Chemical Health Risk Assessment) for VCIs. They used a variety of standard personal protective equipment (PPE), including safety helmets, shoes, gloves, glasses, and masks; along with some specialty PPE such as a raincoat (for air lancing), full face shield, and disposable hooded work coverall (for chemical handling).

In this case, VCI application involved injection through the ring wall. First, the crew had to scan the concrete to identify areas where it could drill through without hitting any reinforcing metal. Concrete coring followed, creating both VCI injection points and openings to insert electrical resistance (ER) probes (for corrosion rate monitoring). A chime seal was applied next to eliminate any gaps between the tank and the ring wall where corrosives could either enter the space or VCI could exit it. Workers also capped large holes where the concrete ring wall was obviously cracking.

Using the holes that had been drilled, workers conducted air lancing to remove enough sand for the placement of ER probes and VCI injection tubes. They inserted the ER probes and started corrosion monitoring two

Air lancing to remove sand. Image courtesy of CorrTrol.

Material Matters continued on page 27

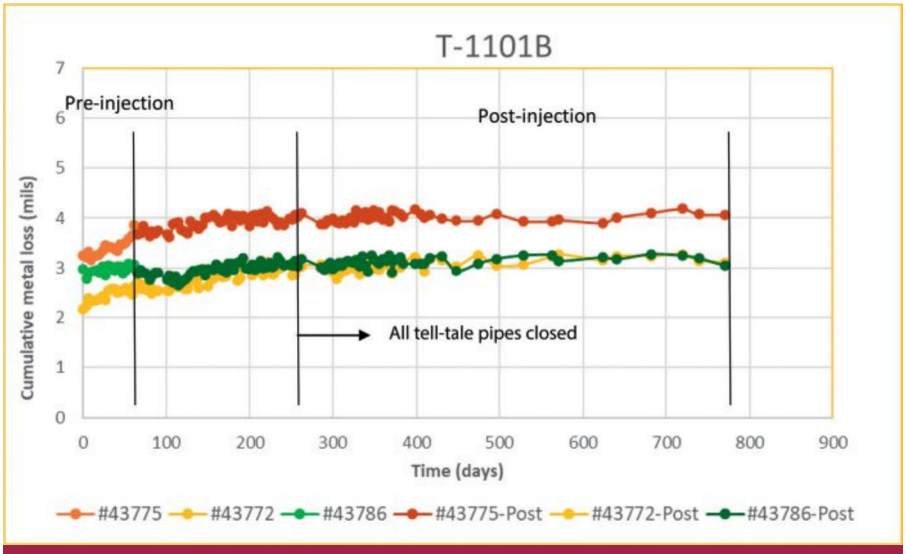
Material Matters continued from page 13

months before VCI injection in order to collect comparison data. At the end of two months, workers pumped VCI slurry directly out of 5-gal (19 l) buckets and underneath the tank floor. Once this was complete, corrosion rate data based on ER probe metal loss was logged repeatedly for the next two years. Over this time, the cumulative metal loss hovered between 3 and 4 mils, showing an average reduction in corrosion rates of 81% following VCI application.

The client was pleased with the project and awarded CorrTrol a service contract in July 2023 to protect additional tanks. As of June 2025, CorrTrol had performed five VCI tank applications, with 14 more in the lineup.

As a newly accepted industry standard with three decades of field application, VCIs are ready to be unleashed for the benefit of tank owners around the world. With VCI's advantages in convenience, cost, and effectiveness, alone or alongside CP, it is only a matter of time and awareness before its adoption becomes as familiar as its predecessors. MP

—By Julie Holmquist (Cortec), Kang Kim Ang (CorrTrol), and Eric Uutala (Cortec)



Corrosion rate data from ER probes, before injection, after injection, and after closure of tell-tale pipes. Image courtesy of CorrTrol.

Job at a Glance

Project: VCI application for protection of firewater tank at chemical manufacturing plant

Location: Malaysia

Date of Completion: December 2019

Contractor: CorrTrol

Size of Contractor: ~20 employees

Size of Crew: 10 workers (including concrete coring and sand air lancing subcontractors)

Prime Client: Petronas Chemical MTBE

Condition of Tank:
Thirty-year-old tank with spent magnesium anodes for galvanic cathodic protection.

Size of Tank:

Diameter: 21.3 m (70 ft)

Area: 356 m² (3832 ft²)

Duration: 3 months

Unusual Factors/Challenges:
Possible rain, sand disposal, and Chemical Health Risk Assessment documentation.
Poor concrete ring wall condition presented a potential application challenge. Safety concerns existed with using a high pressure compressor. Extra time was needed for sand air lancing and inserting VCI injectors.

Safety Considerations:
Used standard PPE plus raincoat (for sand), face shield, and disposable hooded work coverall for chemical handling.

References

1 S.R. Rials, J.H. Keifer, "Evaluation of Corrosion Prevention Methods for Aboveground Storage Tank Bottoms," *MP* 32, 1, cited by Tim Whited, "Use of Corrosion Inhibitors for Control of Corrosion in Double Bottom AST's" https://www.cortecvci.com/Publications/Papers/AST%20Corrosion%20Inhibitor%20Process%20v2.pdf%20 (accessed June 20, 2025).

2 A. Meroufel, K. Abed, M. Al-Hajri, "Mitigation of Soil-Side Corrosion on Storage Tank Bottoms in the Absence or Deficient of CP System," 16th Middle East Corrosion Conference & Exhibition, paper no. MECCFEB16-7995, (Houston, TX: NACE International, 2016).

3 T. Whited, X. Yu, R. Tems, "Mitigating Soil-Side Corrosion on Crude Oil Tank Bottoms Using Volatile Corrosion Inhibitors," CORROSION 2013, paper no. 2242, (Houston, TX: NACE International, 2013).

4 K. Abed, P. Panchal, A. Gandhi, "Evaluation of Impressed Current Cathodically Protected Tank Bottoms in the Presence of Vapor Phase Corrosion Inhibitor." Cortec supplement to *Materials Performance*, June 2016, https://www.cortecvci.com/Publications/Papers/Evaluation-of-Impressed-Current-4.pdf (accessed June 20, 2025).

5 T. Whited, A.J. Oluic, J. Holmquist, "Reducing Soil-Side Corrosion in Aboveground Storage Tanks," *Chemical Engineering*, January 1, 2023, https://www.chemengonline.com/reducing-soil-side-corrosion-in-aboveground-storage-tanks/?printmode=1, (accessed June 2, 2025).

6 API TR 655, "Volatile Corrosion Inhibitors for Storage Tanks," (Washington, DC: American Petroleum Institute, 2021) https://www.apiwebstore.org/standards/655.

7 AMPP Standard, "External Corrosion Control of On-Grade Carbon Steel Storage Tank Bottoms" (Houston, TX: AMPP, 2023).

8 Eric Uutala, quoted by Julie Holmquist in "Make Your Airport Part of an Exciting Trend in AST Corrosion Protection." *AviationPros*, 6 May 2025. Accessed 20 Jun 2025 <https://www.aviationpros.com/airports/article/55287796/cortec-corporation-make-your-airport-part-of-an-exciting-trend-in-ast-corrosion-protection#new_tab>.

9 CorrTrol, "List of Major Projects," https://www.corrtrolgroup.com/images/Project%20Reference-2010.pdf.