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NEWS ALERT

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Aboveground Storage Tanks (ASTs): Tank Bottom Protection with Vapor phase Corrosion Inhibitors

Aboveground Storage Tanks (ASTs) are used to store several types of liquids, many of which are considered hazardous. This requires the tanks to be designed to prevent spillage of the contents onto the ground or into the atmosphere. One of the many design considerations is the impact of corrosion, especially on the tank bottom. For many years, the only acceptable methods of corrosion prevention were assuming a conservative corrosion rate and making the bottom plate sufficiently thick to meet design parameters (including design life and anticipated corrosion rate), or the use of cathodic protection (CP).

Tank owners have long struggled with the fact that the corrosion rate (mpy) is greater than the design allowance due to soil conditions and environment underneath the tank. CP only protects areas where the tank bottom is in solid contact with the soil. As the fluid level in the tank changes, it causes the tank bottom to ripple and loose contact with the soil. When this occurs, pockets are created between the tank bottom and the surface beneath the tank. Moisture and airborne chlorides which penetrate under the tank bottom through gaps between the tank annular plates and foundation collect in these pockets creating corrosion initiation sites.

The API Technical Report 655, First Edition, “Vapor Corrosion Inhibitors for Storage Tanks,” was published in April 2021 by the American Petroleum

Institute (API) to provide information regarding the use of Vapor Corrosion Inhibitors as alternatives for prevention of tank bottom soil-side corrosion.

VCI is an acronym generically used to refer to Vapor phase Corrosion Inhibitors, Volatile Corrosion Inhibitors, and Vapor Corrosion Inhibitors. VCIs are based on Fick's law of diffusion, which states that particles move from a region of higher concentration to an area of lower concentration until equilibrium is reached. The vapor-phase molecule will volatize/sublimate until it reaches equilibrium pressure within an enclosed volume. Once equilibrium is reached, diffusion shuts off like a pressure switch. When the equilibrium pressure drops to a certain level, the inhibitor becomes active. This process continues until all the inhibitor is depleted. Corrosion prevention is achieved by hydrophobic action and ionic bonding as the inhibitor is adsorbed onto the metal surface.

This link (**https://www.youtube.com/watch?v=TC5cTZLYdS0**) demonstrates the movement of vapor molecules from an area of high concentration (the emitter cup) to an area of low concentration (box holding the motor) and the molecules attaching to the metal.

Once a surface has been conditioned with the inhibitor molecule, the presence of moisture (water) does not impact its ability to provide corrosion protection as demonstrated by this time lapse video (**https://www.youtube.com/watch?v=1b89V34lXfk**).

The previous videos demonstrate the phenomena occurring underneath the tank bottom once the inhibitor is injected. Another link (**https://www.youtube.com/watch?v=6f0m14LwYqY**) demonstrates the application of VCI under an in-service tank.

VCI can be applied in the following manner:

New Tank Construction (Options)

- VCI powder can be mixed with the sand prior to installing the tank bottom
- VCI can be placed in Tyvek®* pouches which are placed in a wagon wheel design around the tank
- Injection tubes can be installed for application when required after tank is placed in service
- Provisions can be made to install electrical resistance (ER) probes to monitor corrosion rate

In-Service Tanks

- Drill the required number of access ports in the ring wall and
  - Pump in a VCI in liquid form
  - Pump in a VCI in powder form
- Seal all application ports to minimize leakage between the external atmosphere and the volume underneath the tank bottom

Out of Service Tanks (Options)

- Drill the required number of holes in the tank bottom for VCI application

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    - After application, weld seal plates in place
- Drill the required number of access points in the ring wall and
    - Pump in a VCI in liquid form
    - Pump in a VCI in powder form
- Seal all application ports to minimize leakage between the external atmosphere and the volume underneath the tank bottom

Typical configuration of single and double bottom tank applications can be seen in **Figures 1-4**.

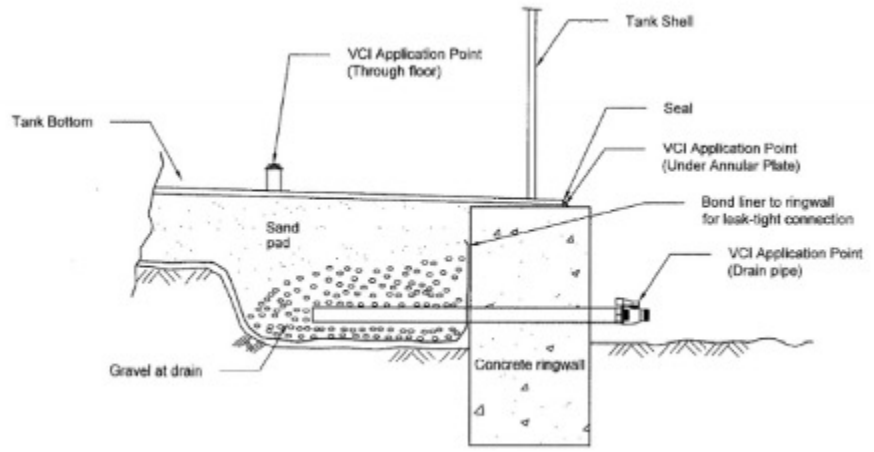

Figure 1 - Generic VCI Application Points [1]
In addition to drainpipes, it may be necessary to drill additional injection ports to assure uniform distribution of inhibitor under the tank bottom.

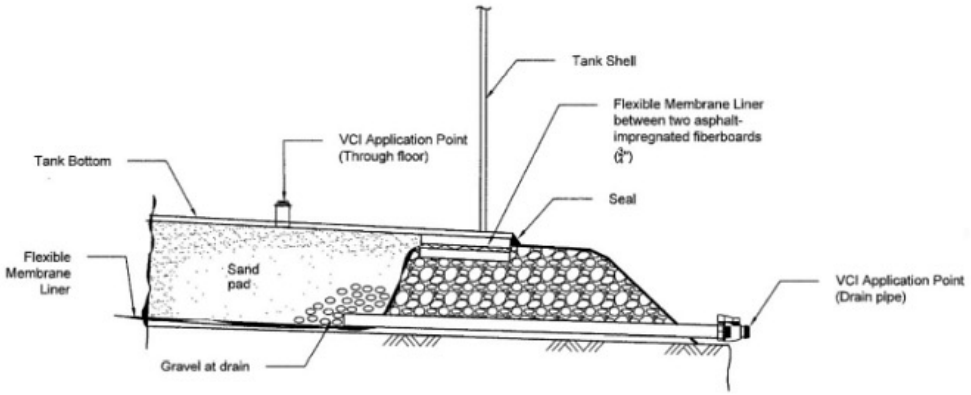

Figure 2 - Single Bottom with Release Prevention Barrier (RPB) [1]

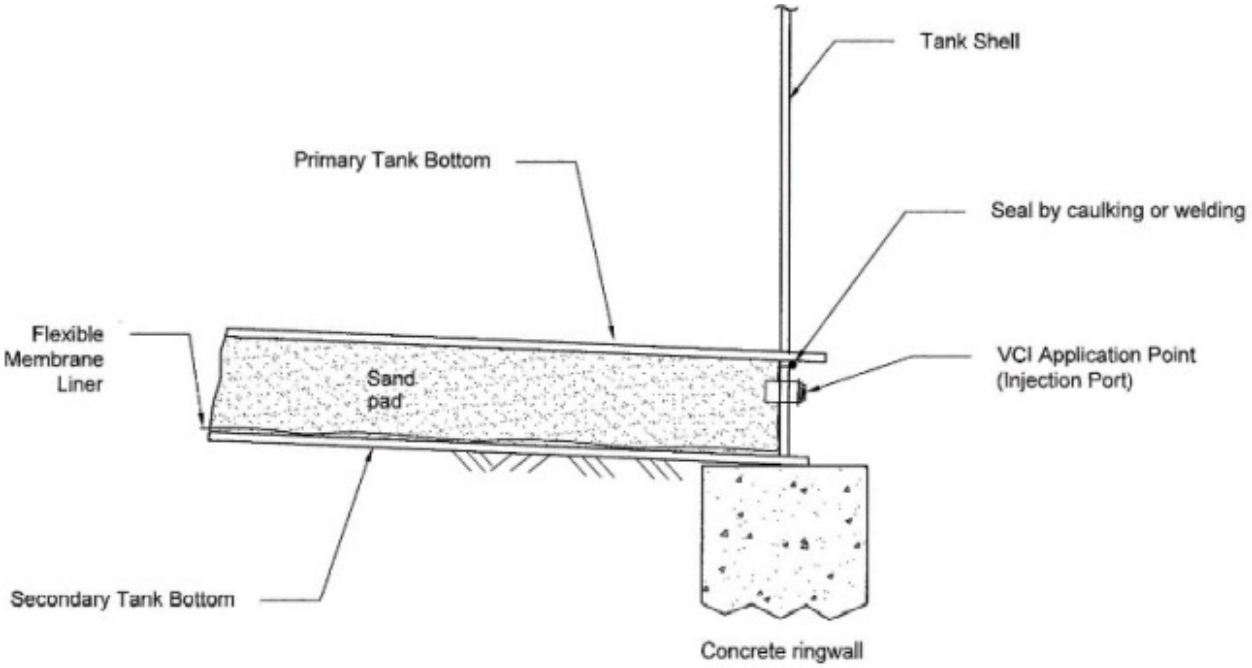

Figure 3 - Double Bottom [1]

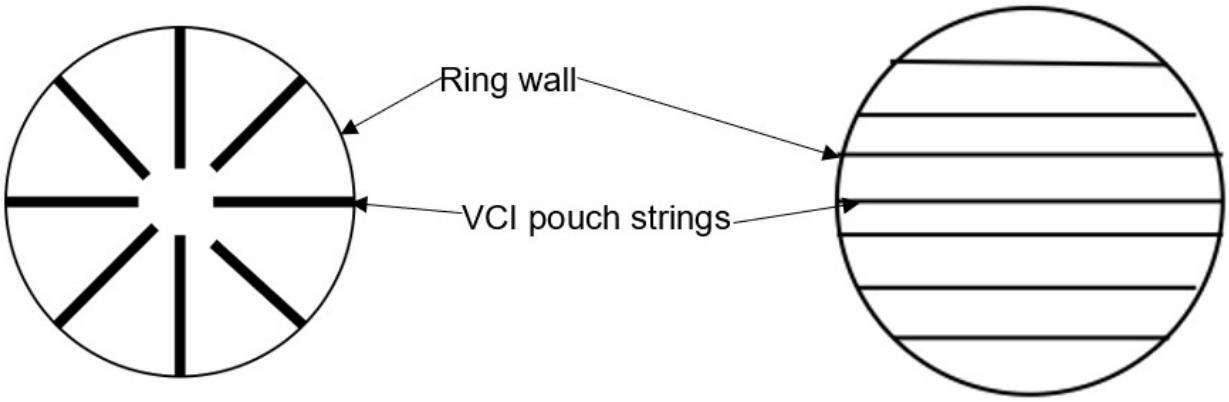

Figure 4 - VCI Pouch Strings for New Construction [1]

Regardless of tank status, procedures should be put in place to minimize leakage between the external atmosphere and the volume underneath the tank bottom by caulking between the tank bottom, the ring wall, and any fittings such as ER probes that will be left installed. Each application procedure should be engineered based on tank geometry, soil conditions, and environment to ensure optimal product and application procedures are used. It is good engineering practice to install the ER probes at least three months prior to application of the VCI to establish a solid base corrosion rate. This rate will be used to determine the effectiveness of the inhibitor and if additional product is needed prior to the next scheduled inspection.

API Standard 653 requires that tanks must be inspected every 20 years at minimum.[2] VCI injection/application systems should be designed for a ten-year service life which is mid-way between two required test and inspection (T&I) periods. It may be necessary to replenish the inhibitor prior to ten years based on the information obtained from the corrosion monitoring system. Injection systems consist of a network of pipes installed through the ring wall and embedded in the sand pad. The number of injection pipes is based on tank diameter. Each pipe is perforated with drilled holes and/or slots located axially along the pipe. Hole/slot sizes and spacing are predicated on tank diameter. This design ensures uniform distribution of the inhibitor across the entire surface area of tank bottom plates. The injector tubes can be extended to within 9.8 ft (3 m) of the tank center as shown in **Figure 5**. However, all injection pipes are not extended to avoid overlapping, assuming the inhibitor can diffuse 16 ft (5 m) from either side of each injector tube. Therefore, some tubes extend close to the center and some have a specific length depending on the tank diameter. Data collected from tanks protected with VCI in various countries indicate a drop in corrosion rate within three months after VCI injection (see **Figure 6** for example). Magnetic Flux Leakage (MFL) testing during T&I of these tanks revealed the tank bottom to be well protected.

Standard ER probes without cables (5 ft [1.5 m]) are installed underneath the tank bottom to monitor annular plate corrosion. Annular plate corrosion is the predominant corrosion area for tank bottoms. Probes with cables can be installed to greater depths, but are difficult to replace, if required. ER probe measurements can be obtained manually, by download of stored data, or by continuous transmission of data via a remote monitoring unit (RMU). The RMU is the only method which provides real-time data that can be used to identify spikes in corrosion activity.

API publications are issued to address industry problems of a common nature and recommend/identify industry proven solutions.[1] Since 1986, the industry has been using VCI in-lieu-of and in conjunction with CP to combat tank bottom corrosion.[4] VCI effectiveness has been documented by research and field work by various organizations. API TR-655 was issued to give tank owners/operators information and guidance on the use of VCIs to protect Aboveground Storage Tank (AST) bottoms from soil-side corrosion.[1] This technical report relates specifically to the amine-carboxylate group of VCI products.[1]

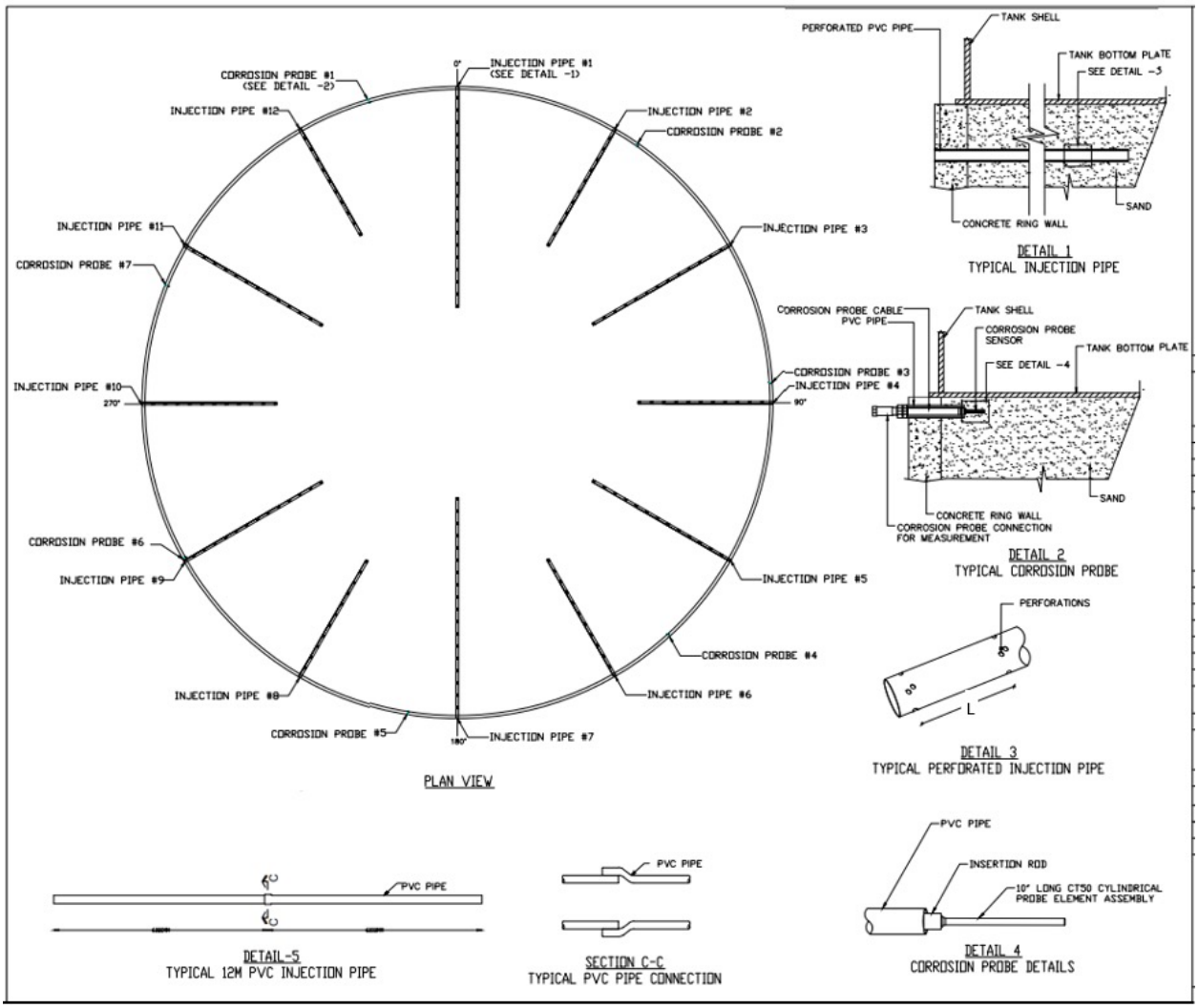

Figure 5 - Typical Layout of ER Probes and Injection Tubes

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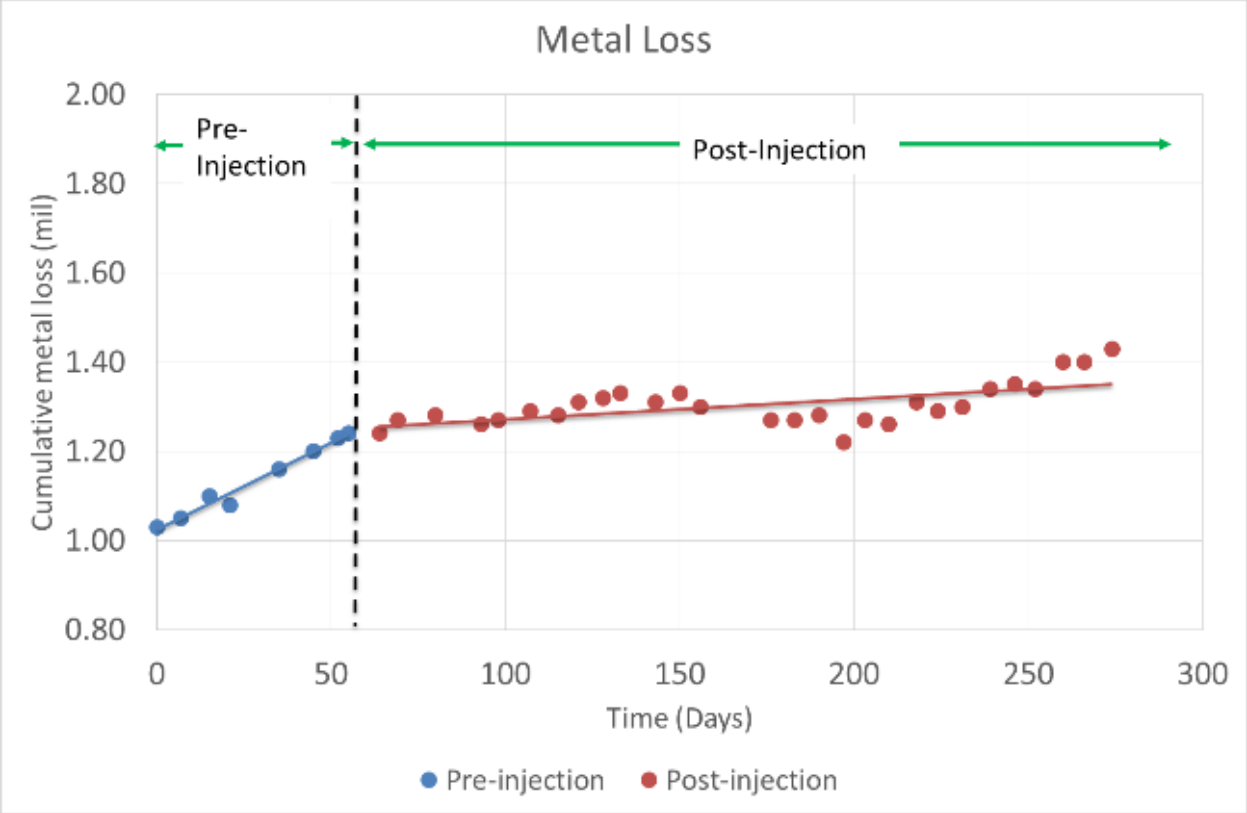

Figure 6 - Metal Loss Before and After Injection [3]

References:

1. ***American Petroleum Institute (API). "Vapor Corrosion Inhibitors for Storage Tanks." API Technical Report 655, First Edition, April 2021.***
2. ***API. "Tank Inspection, Repair, Alteration, and Reconstruction." Standard 653, Fifth Edition, November 2014.***
3. ***Rennie, Stuart. "Stopping soil-side corrosion for tank floor bottoms." 18 July 2018, https://www.linkedin.com/pulse/stopping-soil-side-corrosion-tank-floor-bottoms-stuart-rennie/. Accessed 21 July 2021.***
4. ***Miksic, Boris, et al. "Storage Tank Protection Using Volatile Corrosion Inhibitors." https://www.cortecvci.com/Publications/Papers/Storage_Tank_Protection_Using_VCI.pdf. Accessed 21 July 2021.***