Standing strong with VCIs

Ted Huck, Matcor, proposes how vapour corrosion inhibitors (VCIs) can be used to combat corrosion damage on tank bottoms.

Large diameter aboveground storage tanks (ASTs) are typically built on top of a sand or soil prepared foundation with a concrete ring wall around the perimeter of the tank. During construction, the steel tank bottom plates are placed on the prepared foundation and welded to form a single tank bottom. The underside of these plates are subject to soil side corrosion. For tanks containing hydrocarbons or other hazardous materials, cathodic protection (CP) combined with a secondary containment liner is usually required to prevent corrosion and release of product into the environment – in the US those regulations are administered by the Department of Transportation's Pipelines and Hazardous Materials Safety Administration (PHMSA). While CP has proven to be quite effective at preventing soil side corrosion, these systems are not perfect, have some limitations, and they have a finite service life. One of the exciting new technologies that has emerged to help prevent exterior tank bottom corrosion is the use of vapour corrosion inhibitors (VCIs). This article will discuss the use of this technology for protecting AST tank bottoms.

CP limitations

CP has a good track record for protecting the external bottom of ASTs. This is recognised by the regulatory bodies that mandate it and by industry standards from organisations such as the American Petroleum institute (API), American Water Works Association (AWWA), and Association for Materials Protection and Performance (AMPP) that all have detailed specifications discussing the appropriate use of CP for this purpose. There are, however, limitations to CP. Some of the key limitations include:

- Poor soil side contact – CP only works when the tank bottom is in intimate contact with the sand/soil foundation. If there are bulges in the tank bottom plates, or if the tank flexes when empty or only partially full, or if the sand bottom foundation is improperly compacted leaving voids, then CP would not be able to protect the tank bottom plate that is not in contact with the sand/soil.
- Poor choice of sand/soil padding material – the choice of sand/soil bedding materials can have an impact on the performance of CP. This is especially true with the use of sand mixed with oil or asphaltic material and some clay materials which can impede the consistent distribution of current along the tank bottoms.
- Sumps and drains – sumps and drains installed after the initial foundation compaction may create a localised area adjacent to the sump or drain with poor compaction leading to unprotected areas around the sump. In some cases, the CP system around the sump or drain can be damaged during the installation and this can lead to areas of poor CP current distribution.
- Out of service – most AST CP systems are impressed current systems and require a properly adjusted and maintained power supply and regular testing. If the power supply is not operating (tripped circuit breaker, lightning strike, someone turns it off, etc.), the tank is not protected. Over time, anodes deplete and reach the end of their useful service life and occasionally systems fail prematurely. For tank CP systems that are directly between a high-density polyethylene (HDPE) secondary containment liner and the tank bottom, a failed CP system cannot be accessed for repair or replacement without taking the tank out of service and replacing the tank bottom.

What is VCI?

VCIs are chemestries that slowly release a corrosion-preventative compound into the sand/soil pad. The VCI compound vaporises and diffuses throughout the tank bottom over time. The vapour molecules absorb to the metal tank bottom and suppress the corrosion reaction. This formation of absorbed molecules with sufficient concentration creates a protective barrier and with sufficient VCI and time this barrier spreads across the entire tank bottom, even to those areas not in intimate contact with the sand/soil. Some published studies have indicated that the time required to reach full diffusion could take as long as 12 months depending on the tank size, the VCI material formulation, the location, means and quantity of VCI material being installed, and other factors.

How is it applied under a tank?

The VCI material is available in a wide range of delivery methods with the most common being a solid powder form or a mixed slurry liquid form. For new construction tanks or for installation in the interstitial space between two tank bottoms during a tank bottom replacement project, the VCI can be applied in a powder format, often installed in mesh bags inside PVC tubes that allow for a slow release of material. The use of powder installed in bags placed directly in the sand/soil should be avoided as the bags can leave a void space as the material volatises and there is no means for replenishment. Installing PVC tubes allows for future replenishment and does not cause voids in the sand/soil foundation. For existing tanks, the VCI material can be injected through existing leak detection ports as a liquid slurry, and if leak detection ports are not present, injection ports can be installed to facilitate the introduction of the VCI material under the tank. VCI material can also be installed using a chime seal flood by removing the chime seal, installing PVC piping and ports

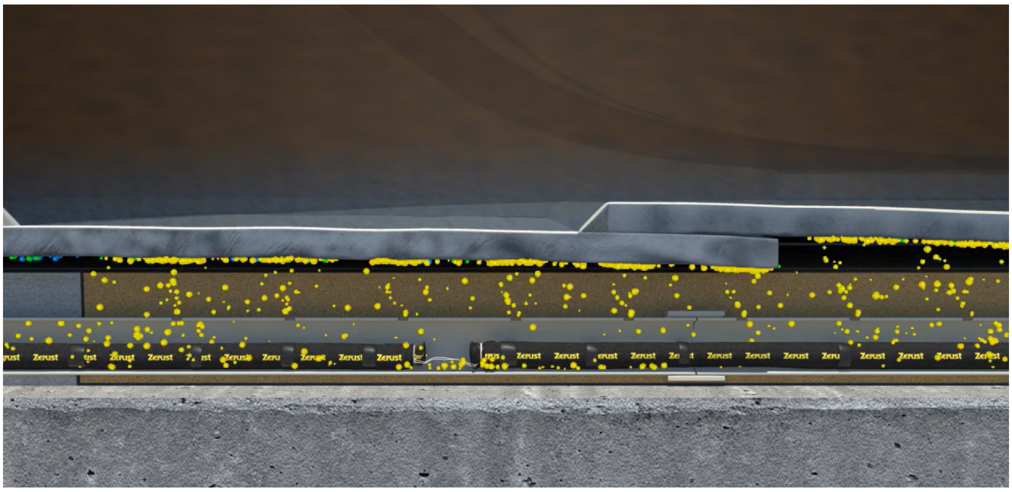

Figure 1. VCI molecules diffusing towards tank bottom from a slotted PVC tube.

for introducing the material under the chime. After installation, the chime seal is restored.

It is important when applying VCI materials to consult with the manufacturer regarding the specific application and the quantity of material to be applied. Achieving an appropriate concentration of vapour molecules distributed over the entire surface to be protected is critical to the effectiveness of the application and in assuring that the system has a reasonable service life before reapplication of new VCI material is required.

Monitoring VCI performance

CP system performance can be directly measured by monitoring the change in electrical potential of the tank bottom resulting from the application of current to the surface of the structure. For VCI applications, there is no means of directly measuring the impact of the vapour molecule absorption onto the surface of the tank bottom structure being protected. To address this, indirect measurements can be taken using ER probes to provide an instantaneous corrosion rate reading.

ER probes measure corrosion and corrosion rates as an increase in electrical resistance over time for a steel element in the probe face. The increase in electrical resistance is proportional to the accumulated corrosion of the probe element over the exposure period. The liberal use of ER probes placed in strategic locations around the tank near the tank bottom provide a good indication of the corrosion rate for the tank bottom based on the assumption that the VCI diffusion and absorption on the ER probe is similar to that of the nearby tank bottom. One limitation of ER probes is that they provide a good measurement of the general corrosion rate but may miss localised pitting corrosion, so it is important that owners understand this risk and continue to maintain a regular direct inspection programme complete with full tank bottom floor scans.

Over time, the VCI concentration will diminish as product leaks out from the confined space under the tank. Eventually, the VCI material will need to be replenished to maintain a proper concentration to ensure that the protective barrier preventing corrosion is sustained. The frequency of replacement will vary based on a range of factors but maintaining a good seal chime is one key factor that can help extend the life of a VCI system and should be given additional attention in tanks relying on VCI as a primary or secondary corrosion prevention tool. For most tank applications, a reasonable replenishment rate timeframe should be 10 or more years, but it is important to consult with the manufacturer based on the specific application details to develop a predicted replenishment period and then use the ER probes to validate the performance and, where necessary, adjust the replenishment period.

VCI working in conjunction with CP

VCI can address or supplement many of the concerns and limitations with CP. They provide an additional layer of protection and can migrate to areas that CP cannot properly protect. Extensive testing and field studies have shown that VCIs can be used in parallel with CP systems to provide additional CP. When using VCIs in conjunction with cathodic protection it is important to note that the introduction of VCI changes the environment directly around the tank bottom and this must be considered when evaluating CP system effectiveness using the potential shift criteria. The depolarised potential with no applied CP will shift after the introduction of VCI chemistry under the tank and a new baseline depolarised potential should be established for CP testing purposes.

VCI where CP has failed and cannot be fixed

For tank owners with dedicated CP systems installed directly under the tank bottom and isolated by an HDPE or other non-conductive plastic sheet liner, there is no good solution when the CP system fails either prematurely or after reaching the end of its operating life. There is simply no practical way to fix or replace such a system without taking the tank out of service and removing/replacing some or all of the tank bottom, even if that tank bottom has no signs of corrosion. VCI is a viable and often cost-effective option to provide corrosion protection without the costly effort needed to take a tank out of service.

Regulatory environment

VCIs were first introduced as a potential solution for tank bottom corrosion in the early 2000s. As with any emerging technology, the regulatory requirements and industry standards and specifications are slow to adapt and incorporate new technologies. This is certainly true with VCI applications for tank bottom corrosion; however, multiple studies by industry organisations and key end users have provided strong evidence that VCIs are a viable approach when used properly and the standards committees and regulatory agencies are inching forward with VCI acceptance.

For PHMSA regulated tanks in the US, a special permit is required to use VCI without an effective CP system in place. Special permits can be used for alternate technologies where an industry consensus standard has not been issued, and special permits are often used before PHMSA adopts new regulations on a new technology or practice.

Conclusion

VCI is a 'new' technology that has been applied towards protecting ASTs. They can be employed in conjunction with CP to supplement the corrosion protection and address some of the limitations of CP. VCIs are also a viable corrosion prevention strategy for tanks where CP cannot be applied without draining the tank and replacing all or part of the tank bottom. Thus the use of this technology provides owners and operators with another tool in their corrosion management tool box. T&T