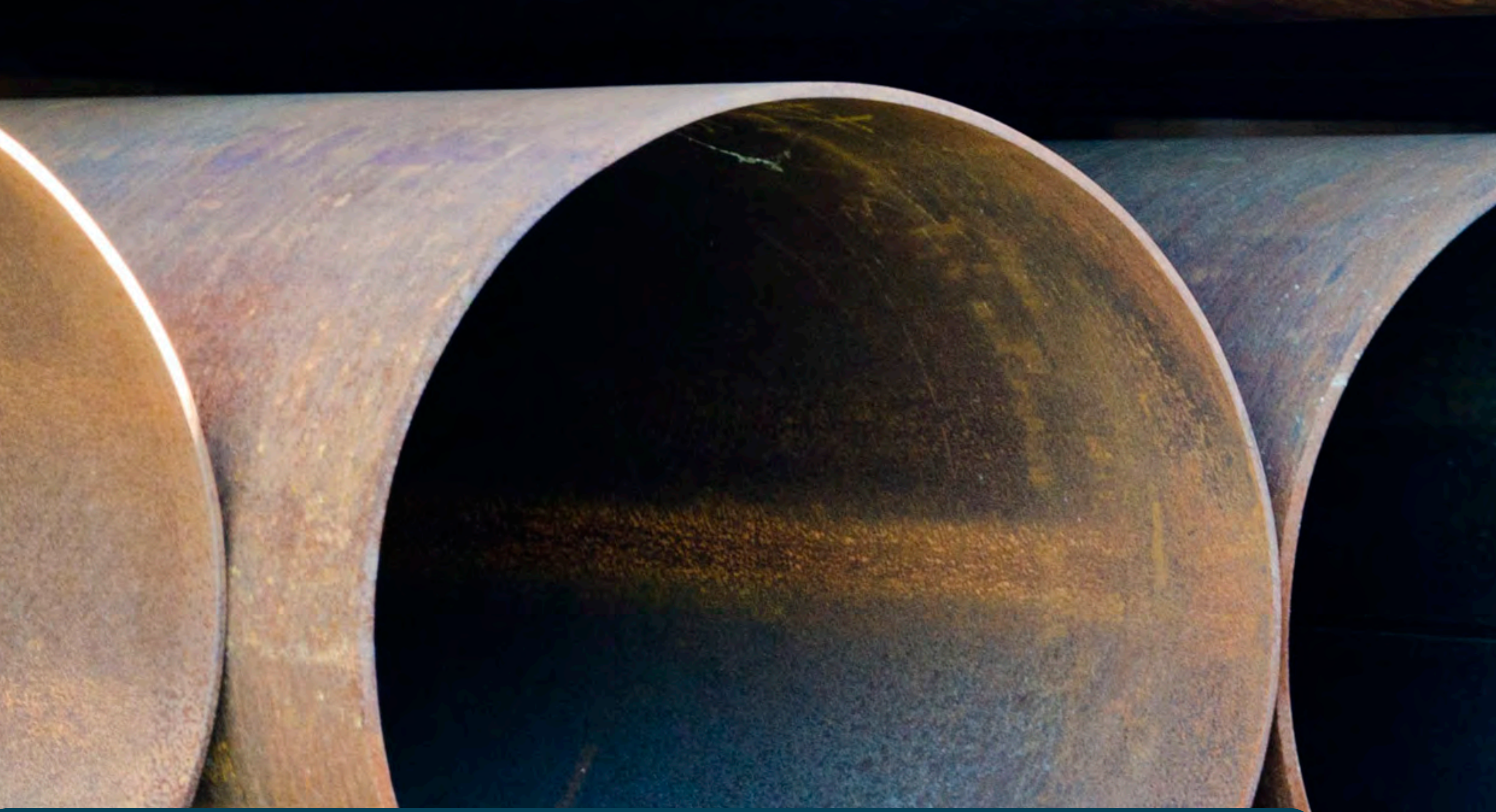
A LOGICAL COMPANION TO CATHODIC PROTECTION



Julie Holmquist (USA), Khalil Abed (UAE) and Philip Horsford (Southeast Asia), Cortec Corporation, explain how volatile corrosion inhibitors quite literally fill significant gaps in the standard cathodic protection system.

Cathodic protection (CP) is well-established as the main method of soil-side corrosion mitigation on aboveground storage tanks (ASTs), according to API 651 and other standards. It is also commonly used to protect underground pipelines. However, it is well known that CP is only effective in areas where the structure to be protected is in direct contact with a conductive electrolyte. Loss of such direct contact leaves gaps in the protection system of cased pipeline crossings and floor-to-soil interfaces on AST bottoms. CorroLogic® VpCI® Technology developed by Cortec® Corporation, US, and distributed by regional providers such as Cortec Middle East and Cortec Southeast Asia, provides a practical complementary method of corrosion protection with significant potential for cost savings and greater asset integrity assurance for asset owners.

CP for ASTs and pipelines: its effectiveness and challenges

CP is a very effective system under the right conditions. For ASTs that have tank bottoms in direct contact with a conductive pad, CP can completely mitigate soil-side corrosion. However, the tank floor-to-soil interface is complex and often includes air gaps where the bottom plate has buckled or the sand has settled. Since the sand carries the CP charge, the presence of such gaps shields the CP current from reaching the metal surface. Another challenge is the continuous increase in sand pad dryness over time, which reduces the amount of CP current needed to achieve the required level of polarisation at the interface of tank bottom plates. The presence of shielding material such as asphalt or oily or bituminous sand in the tank pad renders the CP system only partially effective.

Another challenge faced in CP protected tanks is the feasibility of retrofitting the existing CP system in the presence of a non-conductive release preventive layer such as high-density Polyethylene (HDPE) liners. Retrofitting a defective CP system on an existing AST can be physically labour intensive, time-consuming, and costly, requiring the entire tank to be jacked up in order to access the area below. This may be done simultaneously with tank re-bottoming, which itself carries an expensive price tag in the millions of dollars.[1] Both retrofitting and tank bottom replacement are best avoided, if possible, by more comprehensive protection in the first place that includes the complementary action of volatile corrosion inhibitors (VCI) such as CorroLogic VpCI. The inability to activate the CP system during construction of ASTs, which can take anywhere from several months to several years until the tank is commissioned, leaves the tank floor at risk of soil-side corrosion and eventually impacts the actual service life of the tank. This is an area where VCI can provide the necessary protection for the tank floor against soil-side corrosion until the CP system is commissioned.

Table 1. Corrosion rates on lab tanks with and without CP, pre- and post-VCI injection				
CP status	Tag number	Corrosion rate pre-VCI (mpy)	Corrosion rate post-VCI (mpy)	Percentage reduction
OFF	TK-01	15.44	6.39	59%
	TK-02	10.73	0.91	92%
	TK-03	15.44	0.40	97%
ON	TK-04	2.52	0.29	88%
	TK-05	3.80	0.29	92%
	TK-06	3.50	0.40	88%

Figure 1. Aboveground pipelines are redirected underground at road crossings and placed in casings to protect them from the weight of the road. CP is generally not viable here; however, CorroLogic® VpCI® Filler presents an exciting alternative protection option. Image courtesy of Cortec® Case History 628.

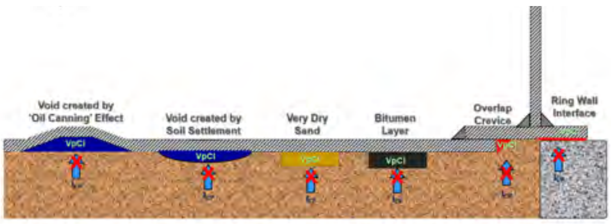


Figure 2. Illustration shows the complex tank floor-to-soil interface and where CP current loses contact with the tank floor and the role of VCI in supplementing CP performance. Image courtesy of Cortec Middle East.

Figure 3. Holes were drilled (and later sealed) to allow injection of VpCI in the form of CorroLogic Slurry. Image courtesy of Cortec Southeast Asia.

In cased pipeline crossings a section of pipeline passing underground is placed in a steel casing or sleeve to protect it against mechanical stresses from the road or railway above. It is also used to provide a means of removing and replacing the pipe section without the need for excavating the road. The use of a steel casing creates an annular space where cathodic protection cannot be used to provide protection for that section of the pipeline.

Benefits of VCI technology

VCI Technology has been gaining increasing acceptance over the last two decades or so as a complementary corrosion prevention methodology to CP. In 2021, this culminated in the publication of the API TR 655 technical report, which provides details on utilising VCIs for protection of tank bottoms against soil-side corrosion. Section 7 of this technical report highlights the synergistic effect between CP and VCI and the effect of VCI on soil resistivity, as well as the possible considerations to be taken into account by owners and tank operators when both systems are combined.[2]

VCIs are marked by their ability to sublimate from solid to vapour form and diffuse through void spaces. They have an affinity to metal that allows them to adsorb onto surfaces such as tank bottoms and create a molecular layer of protection against soil-side corrosion. Cortec Corporation has tailored this technology for use in oil and gas industry applications under the name of CorroLogic. CorroLogic VpCI is based on salts of amine carboxylates that present a low environmental impact and are designed specifically for application in difficult to reach voids underneath tank bottom floors or in pipeline casings. Because CorroLogic VpCI is able to diffuse through sand and space, it is ideal for complementing CP systems in areas of deficiency.

CorroLogic VpCI comes in several forms including CorroLogic Powder, CorroLogic Slurry, and CorroLogic VpCI Filler. The first two can be applied during any stage of an AST's life: new, in-service, or out of service. CorroLogic VpCI Filler is a version designed for injection into casings at pipeline crossings. For AST applications, CorroLogic application often includes four main system components:

- Vapour corrosion inhibitor products (i.e. CorroLogic Powder or CorroLogic Slurry depending on the application methodology).
- Corrosion monitoring system to monitor the corrosion before and after introduction of VCI material.
- A chime area seal system to close the gap between the annular plates and the ring wall.
- Delivery and replenishment network to apply and replenish the content of vapour corrosion inhibitors when needed, during the service life of the solution.

Thus, CorroLogic VpCI provides a lifetime solution by allowing for application, corrosion rate monitoring, and reapplication with minimal invasion on new or existing tanks.

Logical companions?

A logical approach to protecting against corrosion on AST bottoms and cased pipeline crossings would be to combine both CP and VCI technologies to achieve comprehensive protection. In areas where a tank floor is in direct contact with a conductive tank pad, CP will provide full protection. In areas where CP cannot reach (e.g., AST bottom air pockets, cased pipeline crossings), or when electricity is unavailable, CorroLogic VpCI offers protection. As such, CorroLogic serves as an important backup to the standard approach. The question is, are both systems compatible since they both affect the electrochemistry of the tank floor?

Several studies have been conducted to answer this question. In a research work published at the NACE International CORROSION 2016 Conference & Expo, six lab scale tanks were constructed to simulate actual tank construction with an HDPE liner, ICCP (impressed current cathodic protection) system, and ER (electrical resistance) probes. Three tanks had their CP system turned off, and the other three tanks had them turned on. The tanks with their CP system off showed an average corrosion rate of 13 mils per year (mpy) on ER probes, while tanks with CP on showed an average corrosion rate of 3 mpy on ER probes, demonstrating a clear benefit from the CP system. In the second phase of the research, all six tanks were injected with VpCI liquid. The corrosion rate of ER probes in non-CP tanks dropped to an average of 3 mpy. In CP tanks, ER probe corrosion fell to 0.3 mpy. The results indicated that maximum protection was achieved by combining both systems (see Table 1).[3]

Further study suggested that VCI chemistry can work as a cathodic polariser to reduce the amount of cathodic protection current required.[4] However, a sequel study testing two other VCI chemistries found that one worked as a cathodic polariser.[5] This underscores the importance of consulting with CorroLogic engineers to ensure the right VCI chemistry is chosen for best results when pairing VCI with CP.

CorroLogic vs retrofit

A recent CorroLogic installation shows how advantageous CorroLogic can be for protection of in-service ASTs. When a large oil company realised that one of their in-service tanks had an ageing CP system that might not provide sufficient corrosion protection, they evaluated different soil-side corrosion mitigation techniques, comparing CorroLogic VpCI with the option of retrofitting the CP system – in this case, a sacrificial system.

Retrofitting the tank with an equivalent CP system would have been technically challenging as it required horizontal directional drilling in straight lines under the tank while avoiding the remnants of the legacy system – not to mention navigating around the sump and any other buried facilities under the tank. While the CP engineer may have been able to design such a retrofit system, the contractor who would have installed the system highly doubted its feasibility.

In contrast, the CorroLogic system did not require extensive civil works and accordingly diminished the risk of interacting with other systems under the tank. This was a huge benefit to the client from a safety and quality perspective. Commercially, the Cortec system was found to be less than half the overall price of the CP retrofit system, although a single dose of CorroLogic was estimated to have half the design life (10 vs 15 yrs) of a CP retrofit. However, the CorroLogic system could be periodically monitored after installation and VpCI material added if needed to replenish the system after five, 10, or even 15 years. The cost of additional material represents only a fraction of the original total system cost, meaning over a 20 year time period, the CorroLogic system would still be more commercially viable compared to a CP retrofit, thus providing an excellent complement to CP at the end of its service life.

Figure 4. Injection of CorroLogic Slurry beneath an in-service storage tank. Image courtesy of Cortec Southeast Asia.

The client opted for CorroLogic, injecting CorroLogic Slurry beneath the tank and installing a long-term corrosion monitoring system.[6] At the end of a little more than one year, the overall corrosion rate had already dropped by 77%, from 1.85 mpy to 0.42 mpy, on average.[7]

Conclusion

As can be seen, VCI quite literally fills significant gaps in the standard cathodic protection system. Because of its vapour phase action, VCI can protect voids where the CP current is not able to reach — whether in air pockets beneath the tank or in cased pipeline crossings where there is no electrolyte. CorroLogic can provide substantial cost savings as a workaround to avoid the challenges of CP retrofitting on existing tanks. It also has promising indications of potential synergy when used in conjunction with CP. Either way, VCI is an excellent and logical companion to CP for corrosion protection of AST bottoms and cased pipeline crossings.

References

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