


START FROM THE INSIDE OUT

A photograph showing a view through a window from a dark interior to a bright mountain landscape. The window frame is made of dark wood or metal. The landscape outside features rugged, rocky mountains with patches of green vegetation under a clear blue sky with a few wispy clouds. The text is overlaid on the upper part of the window view.

Julie Holmquist, Cortec Corporation, USA, explores how prioritising the internal preservation of pipelines can help solve corrosion problems.

Being aware of the right corrosion solutions can change one's whole perspective on pipeline protection and make some of the most challenging jobs much easier. Rather than relying solely on conventional

methods of protection such as coatings, cathodic protection, or nitrogen, which may not be the most economical or effective options for internal applications, pipeline companies should consider the benefits of vapour corrosion inhibitor (VCI)

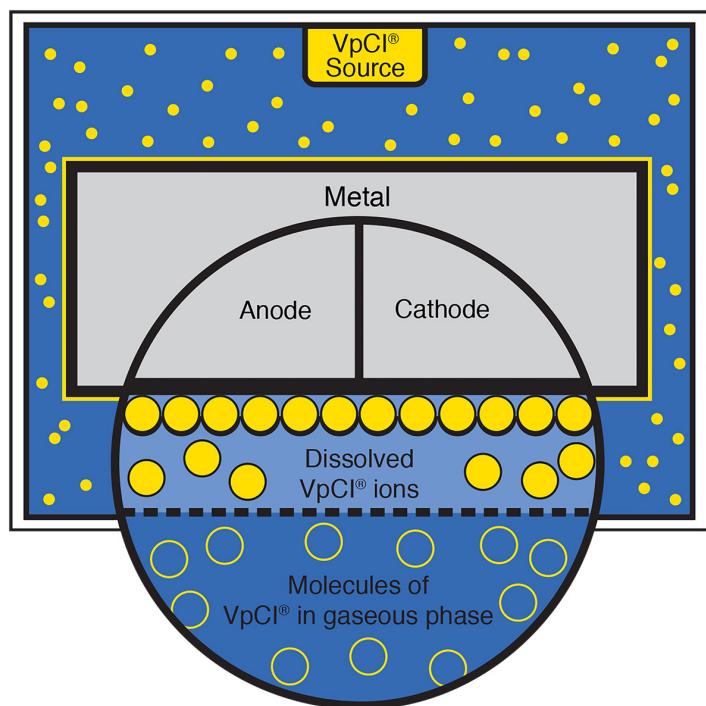


Figure 1. How VCI chemistry forms a protective molecular layer on metals inside enclosed environments. Image courtesy of Cortec Corporation.



Figure 2. Pigging was performed prior to VCI application. Image courtesy of Cortec Middle East.

chemistry. This allows them to address the problem of pipeline corrosion and prevent premature failure starting from the inside out.

Taking advantage of VCI chemistry

VCI chemistry is particularly suited to protect difficult-to-reach internal voids of pipelines, because of its ability to vaporise and diffuse throughout an enclosed space. VCIs come in many formats and can be combined with a variety of different carrier materials for easier application. Some of the best VCIs on the market are those based on salts of amine carboxylates and manufactured by Cortec Corporation in Saint Paul, Minnesota (US). These VCIs have been used in countless applications across the globe, including small and large greenfield and brownfield preservation projects for major oil and gas companies.

VCIs have enough partial vapour pressure to sublimate directly from a solid to a vapour. As the molecules vaporise, they diffuse throughout the air (similar to the action of an air freshener) until they are evenly spaced in an enclosed environment. At this point (equilibrium), their attraction to metal surfaces engages, and they ionically adsorb onto nearby metal surfaces, forming an invisible molecular layer. Under normal circumstances, a metal such as carbon steel would eventually react with oxygen and moisture to form rust on the metal surface. However, the VCI layer interrupts this reaction because the metal ions are not free to interact with the oxygen or the electrolyte. Instead, they are occupied with a temporary attachment to VCI molecules. Because VCIs can migrate throughout an enclosed space, they do not need to be applied directly to each metal surface in order to provide thorough protection, increasing their ease of use and effectiveness.

The same vapour-phase action that allows VCI molecules to condition and protect an enclosed metal atmosphere also simplifies the equipment commissioning process, since VCI molecules float away of their own accord when the space no longer remains enclosed. Depending on the specific medium of VCI application, equipment protected with VCIs often can be used immediately without special cleaning or removal (although rinsing is sometimes required and compatibility with final pipeline contents should always be verified before application). This simplifies labour and reduces downtime for putting equipment into service. VCIs can be applied in many different formats and carriers – powders, fluids, gels, and variations – offering an array of options to meet specific needs from one application to another.

Protecting pipelines before installation

When considering corrosion prevention on pipelines, the first thing that may come to mind is protecting in-service pipelines with corrosive crude oils coursing through them. However, if one is to take a new

approach and look at things from a different angle, it is good to step back even earlier to consider the protection of large pipeline spools still awaiting installation or being



Figure 3. Breathable pouches containing VCI. Image courtesy of Cortec Middle East.



Figure 4. The VCI pouches were draped inside the plenum, and air was injected to carry the sublimated VCI vapors through the subsea pipelines. Image courtesy of Cortec Middle East.

stored as emergency backups. In either case, protecting internals from corrosion is an important part of having viable components to use when they are needed.

VCI technology is an excellent option for these situations. Because VCIs disperse and travel into hard to reach areas, it is relatively easy to provide full coverage in an enclosure that would otherwise be difficult to protect by, for example, trying to apply a coating to all internal surfaces. Instead, workers can easily fog the pipeline spools with a VCI fogging fluid or powder and cap the ends to create the necessary enclosure.

Preservation of LNG backup pipeline spools

This was done to 60 pipeline spools at a laydown yard in the Middle East. The spools were backups for an LNG pipeline. They were externally covered with cement but needed internal protection from corrosion in a harsh outdoor storage atmosphere of strong winds, salt-laden air, and high humidity. One end of each pipe was capped before fogging it with a VCI powder and capping the other end to provide protection for at least two years (or potentially longer with proper inspection). At one point when the pipes were opened for inspection, there was no corrosion except for some remaining surface corrosion that had appeared in some areas prior to preservation.¹

Restoring and preserving subsea pipeline connectors

Smaller components are even easier to protect, since they can be completely encapsulated in a VCI environment for storage. This was done to 19 spare subsea pipeline connectors in Egypt. The project underscores how lack of proper protection leads to the extra step of restoration. Prior to preservation, loose rust was removed from the connectors using pressurised air. Then the connectors were soaked in a tank of biobased rust removal fluid, followed by a power wash using a diluted alkaline cleaner to neutralise the metal and inhibit flash rust. After drying, the components were coated with a wet-film corrosion inhibitor. The protective package was completed by inserting VCI emitter cups and shrink wrapping the connectors in an outdoor grade VCI film.²

Protecting subsea pipelines after installation, prior to commissioning

Another critical protection period is after pipelines have been installed but before they have been brought online. It is common for pipeline projects to take years to complete. In the meantime, these pipelines must be protected to remain in good condition until commissioning. Here again, VCIs can play an important role by providing full internal coverage. As usual, there is more than one way to apply them.

During the last decade, an expert in VCI distribution and application by the name of Cortec Middle East (CME) was involved in two projects to preserve sub-sea pipelines in Persian Gulf oilfields. They employed at least two different methods of VCI application – one for short-

term preservation and one for long-term preservation – as follows.³

Short-term preservation began with caliper pigging to ensure a clear path through the subsea pipeline. Intelligent pigging followed, analysing the condition of the pipeline in regard to corrosion and wall thickness. Once the client approved, the pipeline was dewatered and dried. After this, breathable pouches containing VCIs were loaded into a plenum box – dosed according to pipe volume. The box was heated slightly. Then a medium density pig was loaded into the pipeline. Dry air was blown through the plenum, mixing it with the VCI molecules and driving the pig through the pipeline. When the pig came through at the receiving end, workers checked for the presence of VCI using a VCI detection kit and continued injecting VCI-treated air until detection was verified at the receiving end.

For long-term preservation, CME used a VCI fogging fluid that is typically considered a fuel additive and contains a high concentration of VCI. The additive was atomised and forced through the system using nitrogen. When the oxygen level reached below two percent at the receiving end, they did another VCI detection test and closed the end when the test was positive. After enclosing the system, they brought the pipeline up to holding pressure and recorded this using calibrated pressure gauges. Since monitoring of constant nitrogen pressure on an unmanned platform is difficult and expensive, the use of VCI provides a backup preservation plan that eliminates the need to worry should the nitrogen escape.⁴

Protecting pipelines during hydrostatic testing

Another corrosion concern before pipelines are put into service is the risk raised by hydrostatic testing, a common procedure done to ensure pipelines are capable of safely carrying fluids. The problem is that hydrostatic testing exposes pipeline internals to moisture, which naturally promotes corrosion. The dilemma is even worse in offshore or coastal situations where the abundance of seawater presents an inexpensive source of hydrotest water, yet with an even higher risk of corrosion due to high salt content. How can workers make sure the pipelines are safe to use (by hydrotesting) without compromising their future integrity by introducing corrosion at the same time?

This problem can be addressed by pairing the appropriate corrosion inhibitors to the hydrostatic test water to protect the pipeline internals. For freshwater hydrotesting, this is often a combination of VCI and contact corrosion inhibitors that form a protective film inside the pipeline and also release vapour corrosion inhibitors. Other corrosion inhibitor blends rely chiefly on contact corrosion inhibitors and are designed with the high salt content of seawater in mind, while also seeking to reduce environmental disposal concerns.

Protecting annular spaces in cased pipeline crossings

Another opportunity to address large diameter pipeline corrosion ‘from the inside out’ is the matter of protecting



Figure 5. VCI fogging fluid was injected into the skid using nitrogen pressure. Image courtesy of Cortec Middle East.



Figure 6. Using a pressure gauge to monitor VCI application. Image courtesy of Cortec Middle East.



Figure 7. Preparing a cased pipeline crossing for VCI filler application. Image courtesy of Cortec Middle East.

annular spaces between carrier pipes and their casings at road crossings. These pipelines are supposed to be protected from physical damage by having an extra casing around them. However, the casings often become a breeding ground for corrosion as they trap moisture, soil, or other contaminants inside. Wax-based fillers seem to be deficient, and disbonded coatings are another concern – in addition to the higher risk of corrosion at coating holidays and the potential for an electrical short if pipelines settle.⁵

A patented VCI filler technology has been designed to solve this problem. This two-part system forms a VCI-enhanced gel after it has been pumped into the casing. The gel helps protect against the further ingress of water and contaminants, while the VCIs vaporise and migrate to protect hard-to-reach areas such as those where coatings have disbonded.


CME applied the patented VCI casing filler to the annular space of an 18 in. (46 cm) fuel oil pipeline and 30 in. (76 cm) steel casing at two pipeline crossings in Saudi Arabia. The annular space, which had trapped moisture and debris, was first flushed out for a half hour using a VCI hydrotesting additive until the reddish brown water flowing

out turned to yellowish white. The casing was pneumatically suctioned and then pressure tested. Part A and Part B of the VCI filler were injected into the casing until the filler came out the other end. Casing vents were closed, and electrical resistance probes were installed for future monitoring. The procedure was looked upon as a cost-saving option to extend pipeline service life at the crossings, and has now been used by major pipelines in both North America and the Middle East.⁶

Mothballing pipelines going out of service

Sometimes, pipelines that are already installed will also need to be properly preserved for periods of mothballing. There are a number of possible ways to do this with VCIs, either by hydrostatic testing with a VCI additive, fogging a VCI fluid through the pipeline until it can be detected at the other end, or slugging a VCI solution between two batching pigs. In each case, the inclusion of VCIs helps make up for the difficulty of protecting an internal tubular structure.⁷

Conclusion

With the proper corrosion inhibitors, protecting notoriously corrosive areas of pipelines suddenly becomes easier. It is important for pipeline managers to be aware of these options so that they have a full range of practical and effective tools to choose from when addressing some of the most difficult areas of a pipeline to protect. VCIs and hydrotesting inhibitors let you think 'inside out' by solving corrosion problems in the hidden, most difficult to access areas first. 

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