THE SEARCH FOR EQUILIBRIUM

Julie Holmquist, Cortec Corporation, USA, shares how vapour corrosion inhibitor technology can provide protection coverage in pipelines.

Vapour corrosion inhibitors (VCIs) offer an important dimension to traditional contact phase-only corrosion protection because of their ability to protect void spaces. This has been used to advantage in many applications across the industrial spectrum. For example, VCIs can simplify protection of intricate piping internals that are difficult to reach, make it easier to protect metal parts in transit, and improve the safety and cost-effectiveness of mothballing practices. In the pipeline industry, VCIs can be used to provide fuller protection coverage to fight corrosion in pipeline and casing voids. Because they can be combined with a variety of different delivery methods, VCIs have the flexibility to be used in several different aspects of the pipeline industry.

The multiple phases of corrosion protection

Cortec® Corporation has developed VpCI® technology, which encompasses a broad range of corrosion inhibiting solutions and has paved the way for advances in the development and practical use of VCIs. Corrosion inhibitors are available on a continuum ranging from contact-only inhibitors that must be applied directly to the metal they are intended to protect, to vapour inhibitors with high vapour action that do not need to be applied directly to the metal surface, but must be trapped inside an enclosure to keep the vapours from escaping. In between these extremes are combination inhibitors that can be applied directly to metal surfaces, but also release corrosion inhibiting vapours that provide additional protection when trapped inside a void space.

It is important to have access to all inhibitor types, as some are more suited to specific applications than others. While contact-only inhibitors cannot protect surfaces they are not directly touching (e.g. a coating typically only protects the surface to which it is applied), VCIs have the flexibility of being able to protect in multiple phases. For example, if applied to a bottle of water containing steel wool, VCIs dissolve in the water and protect the steel that is immersed directly in the water, while also vapourising to protect the steel wool in the headspace above the water (Figure 2). The dual action also protects at the interface where the air and water meet. While they are not the only form of effective protection, VCIs make up a deficiency of contact corrosion inhibitors by their ability to protect metals in void spaces, where it may not be practical or even possible to thoroughly apply a contact inhibitor.

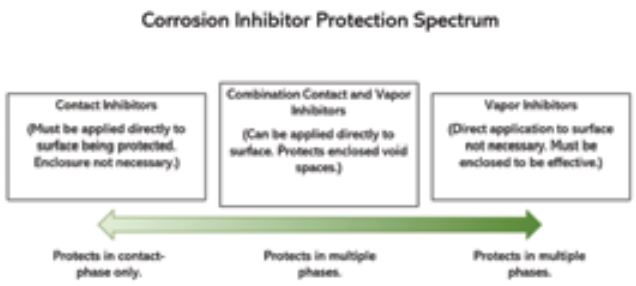

Figure 1. Corrosion inhibitors are available on a continuum ranging from contact-only inhibitors to vapour corrosion inhibitors for void spaces.

Figure 2. Left: The multi-phase action of VCIs protects the steel wool below the surface of the water, above the surface of the water, and at the air/water interface. Right: Steel wool in the bottle is not protected.

VCIs vapourise from their source – whether a powder, liquid, plastic film, or other carrier material – and diffuse throughout the empty void space seeking equilibrium. When the vapour molecules are evenly dispersed, they condense (or adsorb) on the metal surface, forming a protective molecular layer that discourages normal corrosion reactions between the metal and oxygen, moisture, or other corrosives. As mentioned, these vapour inhibitors are very versatile, being soluble in fluids with the ability to provide protection in multiple phases: the contact phase (protecting metals below the surface of the fluid), the vapour phase (protecting metals above the surface of the fluid), and at the fluctuating fluid/air interface.

Protecting pipeline headspace

There are many versatile possibilities for the use of VCI technology in the oil and gas industry. The internal environment of pipelines can become very corrosive from the presence of water and other contaminants in the flow of hydrocarbons. Typically, corrosion inhibitors injected into the pipeline are contact-only inhibitors, flowing along to provide protection to any surfaces the fluid touches. This means any headspace at the top of the pipeline is left unprotected. This can be a problem because the top of the pipeline is also a magnet for the condensation of moisture and acidic vapours. To address this problem, a combination of film-forming inhibitors and VCIs, such as Cortec's VpCI-637 TOL, can be injected into the transmission line for full 360° protection of the internal pipe walls – protecting against both bottom-of-the-line and top-of-the-line corrosion. As with any additive, the compatibility of a particular VCI material for a specific application should be verified before use, as many chemical variables play into a situation.

Protection of pipeline casing annular spaces

Another problem point for pipelines can be cased pipelines, intended to provide protection against physical damage on pipelines located beneath road or railway crossings. However, investigation has shown that these annular spaces can actually be a breeding ground for corrosion. Potential problems include the build-up of moisture and accelerated corrosion at coating holidays. Inline inspection revealed that attempts to mitigate corrosion by filling the casing space with di-electric wax did not suffice to prevent corrosion anomalies similar to those found in casings that were not filled. Protecting areas where coatings had disbonded was another concern. This led to the search for an effective corrosion inhibiting filler material for pipeline casings.[1]

Cortec has since developed the patented CorroLogic® VpCI Filler. This formulation offers the advantages of a gel filler material to discourage the ingress of air and water, while also emitting a VCI that can migrate to and protect difficult-to-reach areas such as those under disbonded coatings. The filler also helps resist bacterial corrosion. The two-part system is mixed just prior to application. After the liquid VpCI concentrate is diluted with water, it is combined with a powder gelling agent before it

is pumped into the void space. This causes the fluid to become viscous and gradually gel once inside the pipeline casing.

Protection of empty pipeline internals

Another area where Cortec has developed practical VpCI corrosion solutions for the pipeline industry is for the protection of pipelines during and after hydrotesting. New pipelines must be hydrostatically tested to make sure there are no leaks, yet this simultaneously exposes pipelines to moisture, which can be corrosive. To deal with this problem, hydrotesting corrosion inhibitors such as VpCI-649 can be added to the hydrotest water. This hydrotest additive forms a thin film that protects on direct contact, but also releases VCIs to help protect the top of the line. After the hydrotest water is drained and the pipeline is capped off, the corrosion inhibitor provides lingering protection. This is an important procedure not only for protection before pipeline commissioning, but also for extended protection of up to two years when a pipeline is being mothballed.

Pipeline segments that have not yet been installed can be protected even prior to assembly, by fogging VCI material through the line and capping the ends to ensure the protective vapours do not escape. This is important for long-term projects where hundreds of pipeline segments are stored in pipe yards, or for situations where pipeline segments will be shipped through corrosive atmospheres, especially overseas.

Case study: field application of gel filler in pipeline casing crossing

In a presentation at the 17th Middle East CORROSION Conference & Exhibition, Khalil Abed, Cortec® Middle East, presented a paper entitled 'Volatile Corrosion Inhibitor Gel Casing Filler: A Field Application'.[2] This paper shared how VCI gel casing filler was applied in real life to a 60 m cased pipeline crossing under a main highway in a west province of the Arabian Peninsula. The 42 in. pipeline was enclosed in a 48 in. steel casing.

Prior to application, the casing was first pressure tested with water containing a corrosion inhibitor additive to confirm casing integrity. To ensure carrier pipe and casing walls were as clean as possible to allow maximum effectiveness of the VCI filler gel, the casing was then flushed repeatedly with corrosion inhibited water until the water turned from brown to a light colour. All water was then pneumatically sucked from the casing. Next, the VCI filler gel was mixed and pumped into one of the casing vents until it started coming out the vent at the other end. After filling, the vents were closed to keep the VCIs trapped inside.

Conclusion

Contact corrosion inhibitors are common and effective, but they do not serve all dimensions of corrosion protection. VCIs allow corrosion protection to go beyond the capabilities of traditional contact-only corrosion inhibitors by protecting metals in void spaces where contact inhibitors cannot reach. This opens the door for protection against top-of-the-line corrosion.

When combined with film-forming corrosion inhibitors, VCIs offer a solution for protection during and after hydrostatic testing, which presents benefits for pre-commissioning and decommissioning activities. VCIs can also be used to protect pipeline segment internals before installation.

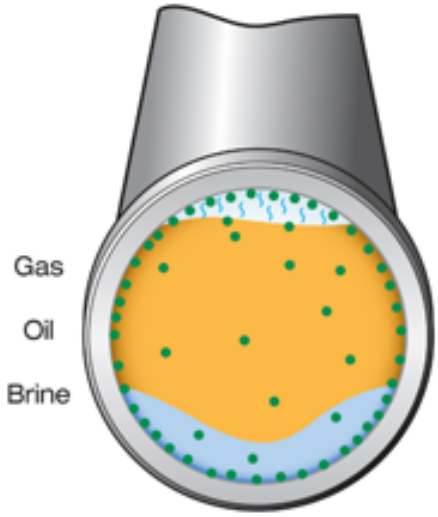

Figure 3. VCI technology enables protection of metal surfaces in contact with the pipeline fluid, and also in the headspace above the fluid where moisture and acidic vapours may condense.

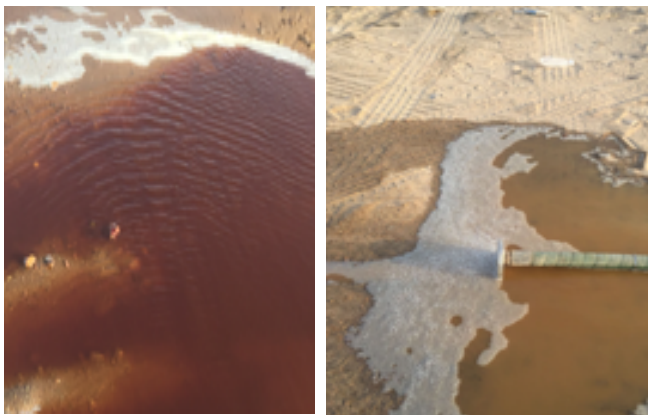

Figure 4. Left: Rusty casing discharge water at the beginning of pipeline casing flushing. Right: Casing discharge water is cleaner after thorough flushing.

Further, VCIs can be combined with various delivery methods to meet unique needs like those of pipeline casings. The development of VCI gel filler material stands as an example of how this can be achieved, to provide a practical new method of corrosion protection for void space trouble areas such as pipeline casings.

By including VCIs in active pipeline flow, hydrotesting, pipeline storage, and gel casing fillers, the oil and gas industry can fill in many of the gaps left unprotected by other methods of corrosion control. WP

References

1. KRISSA, L.J., DEWITT, J. and WHITED, T., 'Development and Application of a New Solution for Mitigation of Carrier Pipe Corrosion Inside Cased Pipeline Crossings,' Materials Performance Supplement, NACE International, June 2014, Houston, Texas.
2. ABED, K. and DAKWAR, N., 'Volatile Corrosion Inhibitor Gel Casing Filler: A Field Application', 17th Middle East Corrosion Conference & Exhibition, Bahrain, NACE Paper No. MECCOCT18-12511, NACE International, October 2018.

Notes

All images courtesy of Cortec Corporation and Cortec Middle East.
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