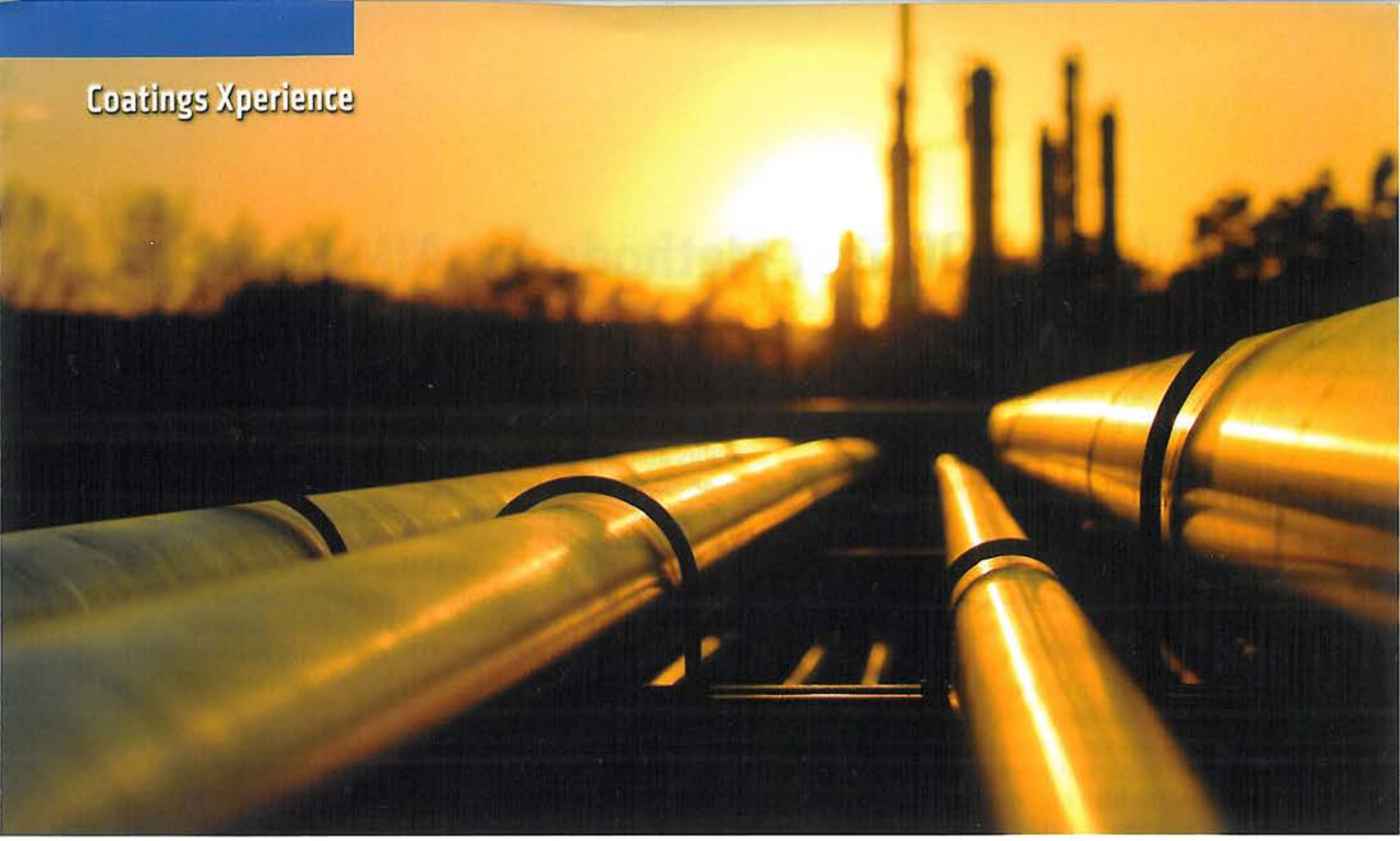

Battling Corrosion with Vapor Corrosion Inhibiting Coatings

In the never-ending war against corrosion, advances in coating technologies for the prevention of damage to metal substrates are constantly being sought. Recent developments in vapor (or volatile) corrosion inhibiting (VCI) coatings are therefore very welcome. VCI coatings can be formulated for both temporary and long-term corrosion protection according to application need. Water-based VCI coatings are also now available that can provide enhanced corrosion protection even at very low film thicknesses, allowing cost savings through the reduction of material and labor usage, and environmental benefits through lower VOC and toxicity.

Conventional corrosion protection coatings contain sacrificial metals [zinc, aluminum, zinc oxide (ZnO), modified ZnO, calcium ion-exchanged amorphous silica gel] or inorganic corrosion inhibiting pigments (chromates) that may contain toxic substances, settle, react with coating resins and often require the use of wetting agents that can reduce performance. In addition, the large relative size of these particles can leave gaps in the coating and allow the inception of micro-corrosion, according to Julie Holmquist, content writer with Cortec® Corporation. Once micro-corrosion has started, she notes that it can spread and cause coating failure.

Vapor corrosion inhibitors are, on the other hand, organic compounds, typically amines, that have electrons that can interact strongly with the polar metal surface and hydrophobic regions that repel water. VCIs incorporated into coatings adsorb onto the metal surface in which they are applied, forming a continuous, self-healing, hydrophobic layer of protection that prevents air and moisture from reaching the substrate. VCIs migrate into voids and micro-cavities beneath the coating, protecting against micro-corrosion and discouraging corrosion "creep" when a VCI coating is scratched or otherwise damaged. The ability of VCIs to evaporate, diffuse, and adsorb onto metal surfaces allows coatings with extra VCI to be applied to enclosed spaces (e.g., pipe internals) to protect surfaces easily missed during coating application.

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Until recently, VCI coatings have largely been used in applications that require temporary protection because traditional formulations were readily removed and often soft and tacky. Industrial coatings often require

(a) (b) (c)

FIGURE 1—Panels showing (left to right) blistering results for water-based VCI (a), solvent-based VCI (b), and coal tar epoxy coatings (c).

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high hardness and gloss. VCI coatings were also traditionally solvent-based. Today, both solvent- and waterborne VCI coatings are available for removable and permanent coating applications (where high abrasion resistance is not required). Vapor corrosion inhibitors are generally soluble in water and organic solvents, but emulsification or the use of co-solvents may be required to incorporate some of them into water-based systems. Additives such as waxes or hard resins, pigments, and/or curing agents are used to increase the hardness of VCI coatings and are selected while keeping the need to maintain good adhesion in mind.

In a recent study, Cortec compared the performance of a common coal tar epoxy coating to both solvent- and water-based VCI coatings under accelerated conditions designed to simulate a steel storm shelter buried underground (*Figure 1*).[1] Holmquist notes that panels with each coating were buried under approximately one and a half inches of dirt and clay and subjected to approximately 1,000 hours of accelerated corrosion conditions in a humid testing chamber according to ASTM D-1735. "The panels protected with the VCI coatings showed minimal blistering, while those treated with coal tar epoxy showed significant (40–50%) blistering," she says.

Addition of NANO-VCIs (small-particle vapor corrosion inhibitors) to a water-based coating containing a nontoxic metal complex inhibitor was also shown to increase its corrosion protection performance.[2] "The study found that NANO-VCIs exhibited a synergistic effect with an ecologically friendly pigment inhibitor, and the NANO-VCI coating passed salt fog chamber testing (520 hours with scribing on the metal panels) with less blistering and corrosion than the coating without NANO-VCIs (*Figure 2*). It was concluded that the ability of the VCI to migrate into microcavities between the particles of the other inhibitor and form a protective film on the surface contributed to the enhanced performance," Holmquist observes.

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FIGURE 2—Corrosion on traditional water-based coating (left) vs. minimal creepage corrosion from scribe on panel coated with 1 mil of NANO-VCI water-based coating (right) after 1,000 hours of salt spray exposure.

Cortec has also developed a low-VOC, clear, water-based, permanent VCI coating that was able to pass 1,000 hours of intense salt spray testing according to ASTM B117, applied at a dry film thickness of just 1 mil.[3]

"One thousand hours of salt spray protection at such thin levels of water-based coating is unheard of," asserts Holmquist. She adds that there are numerous applications for these high performance coatings, particularly where minimal change in substrate appearance for structures and equipment is important. The coating can be left clear for easy substrate inspection or tinted according to need.

In one example, a dealer of heavy equipment in Indonesia was able to coat equipment with water-based VCI coatings tinted to standard equipment colors.[4] "The equipment was stored in a yard near the sea and the paint had begun to blister. Conventional paints were applied but quickly cracked and allowed corrosion in one to two months. In contrast, a three-month inspection of water-based VCI coatings showed effective protection with no further corrosion, even in extreme conditions, and promised to be a viable option," Holmquist explains.

Removable VCI coatings remain important as well. For instance, water-based VCI coatings can be sprayed onto a substrate and allowed to dry into a stretchy film that protects the substrate from both physical abrasion and corrosion. When no longer needed, the film can be peeled off and discarded as solid waste without any need for special disposal requirements, leaving a clean, corrosion-free substrate according to Holmquist. She adds that VCI coatings are particularly suited for protecting pipeline couplings, which can sit for extended periods of time in all types of weather. Use of the easily removable coatings avoids the need for welders to grind rust and contamination off the couplings before use. "Removable VCI coatings also offer advantages for storage or shipment of metal parts and equipment, especially when the equipment is large, oddly shaped, or might have sharp edges that would puncture protective film packaging," Holmquist continues. Clear or tinted removable VCI coatings can be applied to both bare and painted metal and later rinsed off without harming the substrate. In some cases, it is even an option to leave the removable VCI coating on the substrate because of the minimally invasive nature of many VCI coatings. ❊

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