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A Look at Developments in Vapor Phase Corrosion Inhibitors

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A 2002 NACE study estimated that the annual cost of corrosion in the United States alone nears 3.1% of GDP — a staggering \$340 billion! The real-world implication to metal manufacturing and processing is the added cost of doing business. Aside from the most visible effects, such as product failure and rejection, are those "hidden" costs that are part of the everyday manufacturing process. Expenditures on cleaning, blasting, reworking, and disposal combined with labor-intensive additional processing steps greatly affect the bottom line.

In order to combat the devastating effects of corrosion and in an attempt to preserve valuable military equipment, the U.S. Navy tested the first volatile corrosion inhibitor (VCI) chemistry for the mothballing of boilers and similar structures on warships in the late 1940s. The core chemistry at that time was a toxic amine nitrite solution applied to the inside of inaccessible spaces. Although a similar nitrite-based chemistry is still widely used today, there is an effective, environmentally sound, and safer alternative.

A new generation of corrosion inhibitors emerged in the late 1970s. They are called *vapor phase corrosion inhibitors*, and are marketed under the registered trademark VpCI™ of the Cortec Corporation. These new chemistries developed and marketed by Cortec use state-of-the-art, nontoxic organic inhibitors in a wide variety of forms. The VpCI technology, as described in this article, protects metals from corrosion during manufacture, process, shipment, storage, and while in use without any residual contamination to the protected metal. The result is a corrosion-inhibiting strategy that can be applied across the full range of metalworking and manufacturing processes.

A DIFFERENT APPROACH TO CORROSION CONTROL

As we all know, corrosion is the natural process of a material - usually a metal - returning to its original state through an electrochemical process caused by a reaction with the surrounding environment. Although corrosion is a natural process, certain atmospheric conditions to which the metal is exposed during its manufacture, processing, storage, or shipment can aggressively accelerate the degra-

ation. Most notable of these factors are sulfur dioxide (typically associated with the burning of coal, oil, and gas), acids in packaging materials, and temperature and humidity fluctuations during transit.

VpCIs are organic compounds that have *sufficient vapor pressure* under ambient atmospheric conditions to essentially travel to the surface of the metal by diffusion and physically adsorbing onto the surface. In the presence of moisture, the VpCI molecule becomes polarized and attracted to the anode and the cathode of the metal. Once the VpCI protective ions are adsorbed onto the surface, the electrochemical process of corrosion is interrupted as *the ions create a protective barrier to contaminants* such as oxygen, water, chlorides, and other corrosion accelerators. With the protective barrier in place, the corrosion cell cannot form and corrosion is halted. This is shown in Figure 1.

Unlike nitrite inhibitors, which do not have sufficient vapor pressure under ambient conditions, VpCI products can actually protect yellow and ferrous metals as well as soldered parts and alloys. Other corrosion-inhibiting strategies, including water-displacing, water-absorbing, dehumidification, and barrier prod-

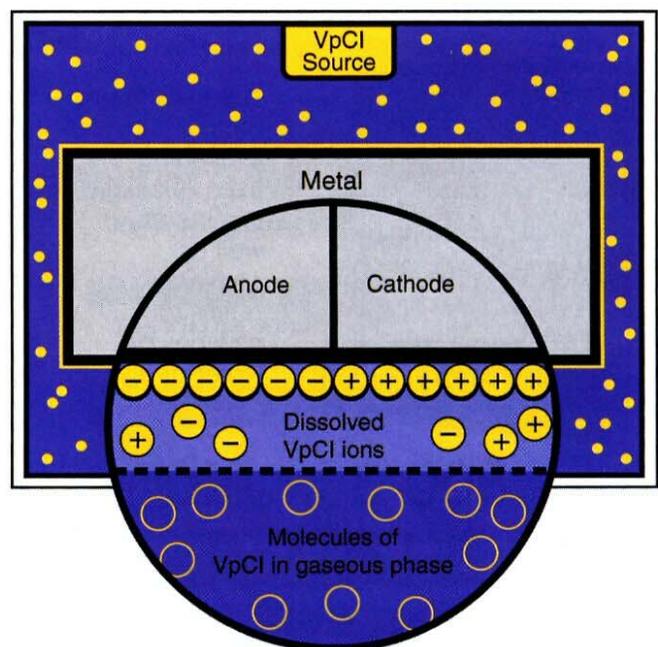


Figure 1. Protective barrier halting corrosion.

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ucts, all function by altering an ever-changing environment surrounding the metal. The VpCI technology focuses on the metal itself, actually passivating the metal's surface. In fact, VpCI molecules actually use the same mechanism that accelerates corrosion to accelerate the release of protection molecules — a built-in defense mechanism.

MANUFACTURING WITH VPCI PRODUCTS

During the typical manufacturing stages for a metal product, the material is cleaned, oiled, blasted, machined, finished, assembled, painted, and packaged. For some products many of these steps are repeated several times. By effectively utilizing the benefits of VpCI technology, many of these in-process steps can be eliminated. The new technology promises other cost savings from reduced disposal and cleanup requirements as well. Imagine a manufacturing process where the starting metal structure is processed without need for secondary oil rust preventives, rework, rust removal, blasting, or multiple cleaning steps.

VpCIs in their pure form are usually off-white powders and can be used in this form for protection

of large void spaces, such as heat recovery steam generators (HSRGs), boilers, turbines, and pipes, previously coated with amine nitrite inhibitors. Additionally, VpCIs can be incorporated into coatings, greases, functional fluids, cleaning systems, hydrotesting solutions, and even concrete and plastics. The result for a manufacturer using VpCI product is streamlined processes, improved product quality and acceptance, and overall cost reduction.

But how do VpCI molecules affect the metal surface? The VpCI molecules are designed specifically to *prevent* reactions on the metal surface. Whereas many methods of corrosion protection alter the metal (i.e., stainless versus carbon steel, cathodic protection, and treatment of metal), VpCIs do not alter the surface as the protective ions are *adsorbed* to the surface rather than becoming *permanently attached*.

The Specialty Lab Incorporated conducted a test on VpCI products to determine how the protective molecules affected the exposed ends of fiber optics cables. Three products were tested including VpCI 125, VpCI 130, and CorPak 1-MUL pouches. The testing showed that there was no indication of

attenuation change caused by the corrosion inhibitors.

TESTING CORROSION INHIBITOR EFFECTIVENESS

While there are many methods to test corrosion inhibiting compounds and methods, the industry standards involve three principle criteria — contact protection, vapor protection, and protection in simulated environments. There are standardized and industry accepted tests for each.

First, will the compound inhibit corrosion when the compound is in direct contact with the metal it is designed to protect? The "Razor Blade Test" is a quick laboratory test with a pass or fail rating — if corrosion exists after the set time frame, the product fails. The Razor Blade Test essentially tests the contact corrosion-inhibiting ability of a material. In most cases, the test is conducted on test coupons and on multiple types of metal.

Second, Federal Standard 101c, the German VIA Test, is used to determine if a corrosion-inhibiting compound will protect a metal when the compound is *never* in contact with the metal. For this test, the

corrosion-inhibiting compound is placed in a glass jar. A metal slug is placed in a rubber gasket attached to the lid, so it is prevented from coming in contact with the corrosion-inhibiting product. This is shown in Figure 2.

Simulating environments through ASTM D 1748 Humidity, ASTM B117 Salt Fog, and ASTM D 53 Prohesion can also be an effective means of evaluating the comparative corrosion protection ability of different products. These tests accelerate the corrosion process by placing the metal samples (either coupons or actual parts) in environmental chambers where atmospheric conditions are monitored and altered.

Many specific, proprietary VpCI™ products also have industry approvals for use in highly restrictive markets such as direct and indirect food contact. VpCI™ 126 Blue film, for example, is suited for the shipment and storage of food processing equipment and has indirect food contact approval from the FDA. VpCI™ 337 has USDA approval for use on packaging material that is in direct contact with meat or poultry food products. Both approvals, as well as many others, are evidence that VpCI tech-

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nology can provide a cost-effective method of superior corrosion protection while remaining nontoxic,

safe for workers, and without affecting the surface of the protected metal.

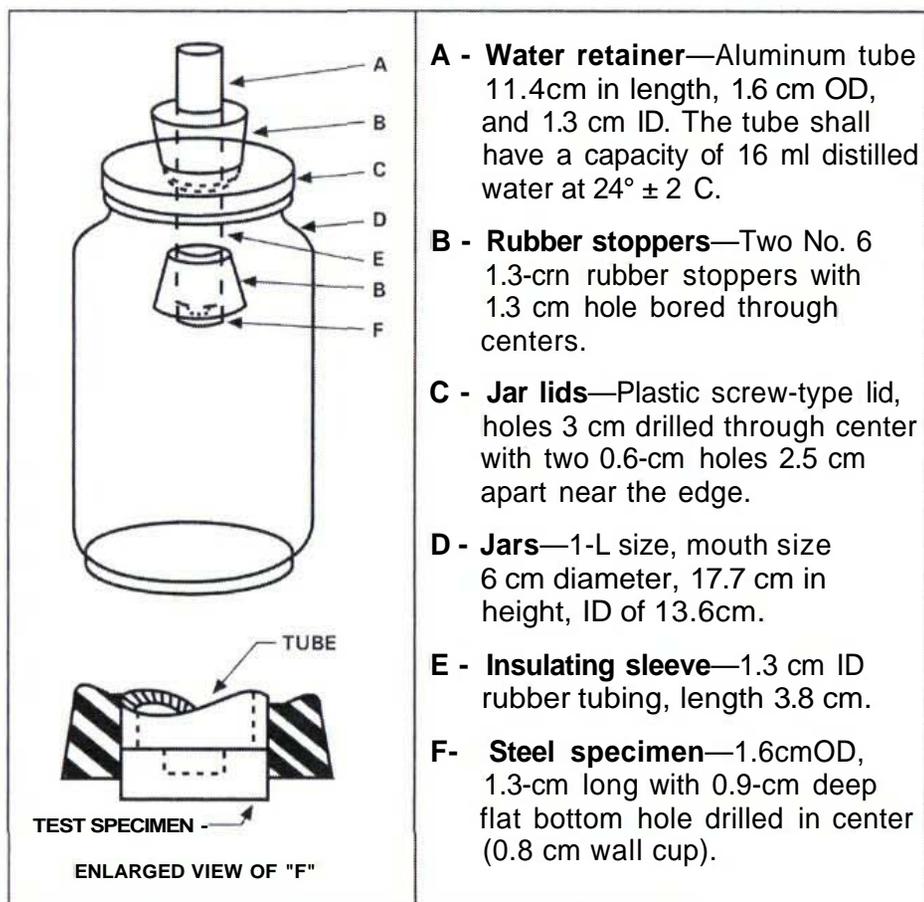


Figure 2. Metal slug placed in rubber gasket.

PRACTICAL PRODUCTS IN ACTUAL USE

A large telecommunications equipment manufacturer was shipping high-value enclosures overseas using barrier film, desiccant, vacuum seal, and humidity cards yet they were still experiencing nearly 85% failure rate due to corrosion. Not only was their packaging and rust preventive method extremely expensive, an even higher cost was encountered when the equipment had to be replaced. Additionally, the packaging was compromised when customs officers were forced to open the barrier film to inspect the enclosures.

Initial shipments were established using only VpCI 111 Emitters and VpCI 126 Blue film. The VpCI 126 Blue film contains VpCI molecules throughout the film and is translucent allowing easy customs inspection. The VpCI 111 Emitters quickly saturate the enclosure with the protective corrosion-inhibiting vapor allowing rapid shipments.

After switching to VpCI products, this manufac-

turer was able to eliminate all corrosion claims while reducing costs by nearly 60% including a decrease in material and labor costs.

The U.S. Air Force has also effectively used VpCI technology as part of its war readiness and equipment preservation methods. Vehicles that would previously have taken nearly a week to clean, drain, reassemble, and operate are now wrapped in Mil-Corr® with only the antenna and battery removed. All fluids in the vehicle including brake, hydraulic, engine, and coolant incorporate a VpCI additive to the existing fluid. The VpCI additive protects even after the oil or fluid has settled into the reservoir.

A large power generation OEM manufactures their heat recovery steam generators (HRSG) in South East Asia. Historically, these units would be full of corrosion upon arrival at their customer's site due to long shipping periods and large temperature and humidity fluctuations. Several years ago they switched to VpCI products in order to protect the high-value generators in transit as well as decrease cost and environmental impact.

United Space Alliance has utilized Cortec VpCI™ technology successfully in the form of a water-based high-performance rust preventive for rocket booster structural components on NASA rockets. The important factors for NASA included rust prevention, cleanliness, ability to topcoat, and the VpCI product could not negatively affect the metal surface. The

VpCI coating is applied to virtually all rocket booster structural components and can also be used for some limited flight applications.

CONCLUSIONS

Corrosion costs industry billions annually and the effects on a manufacturing facility can be catastrophic if proper methods of prevention are not utilized. Research and development continue in the quest for greater capability. Today's state-of-the-art vapor phase corrosion inhibiting products offer users an effective method of protection while maintaining strict adherence to product quality, environmental considerations, worker safety, and even throughput and the bottom line.

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ABOUT THE AUTHOR

Robert A Boyle holds a B.A. from Hamline University (St. Paul, MN) and is currently the Technical Specialist for Integrated Solutions (packaging, metalworking, surface preparation, and coatings) at Cortec Corporation. He holds two patents with several others pending. For the past three years he has been focusing his attentions in the area of environmental attributes of corrosion inhibiting technologies.