The Reason MarineLine® is Better is Because of a Better Chemical Structure

TECHNICAL REPORT

One of the questions customers ask Advanced Polymer Coatings (APC) is "What makes the MarineLine® cargo tank coating better than other tank coatings?" This technical report will answer that question.

The answer begins with understanding basic polymer and coatings chemistry. A coating is a thin layer of material deposited on a substrate to provide various surface properties. For protective coatings, key performance features are corrosion protection, high temperature resistance, low surface energy (for easy cleaning), and others. By using the right chemistry, these properties can be achieved.

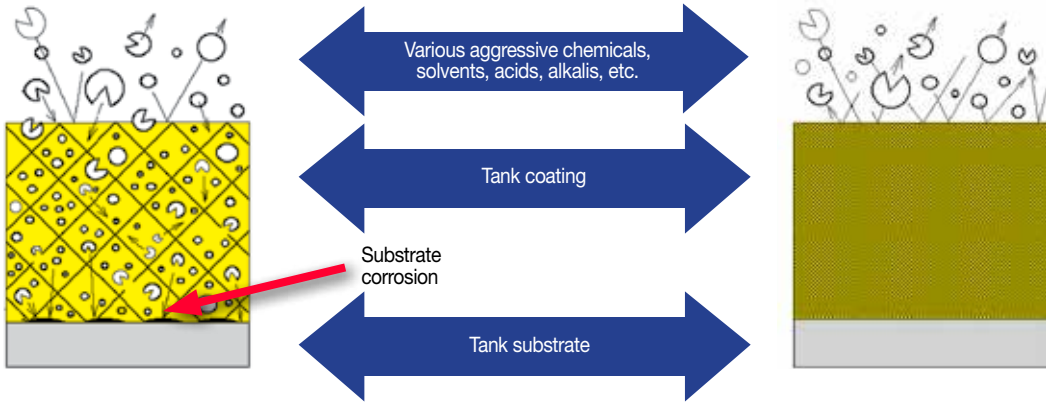
Setting The Bar High for a Cargo Tank Coating

The PROBLEM

Aggressive chemical molecules penetrate into an 'open screen' coating causing absorption and swelling. This leads to subsequent cargo contamination and also substrate corrosion.

The GOAL

Create a high density 'closed-screen' coating allowing virtually no penetration, providing high chemical resistance. An ultra-smooth surface ensures easy, fast cleaning.



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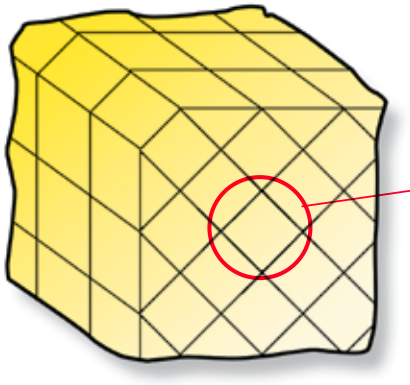
For many years, APC studied a range of polymers and coatings for various applications. This research into epoxies, phenolics, vinylesters, polyesters and zincs, was done to determine what chemical matrixes produced successes, and what weaknesses eventually led to failures or reduced capability to handle aggressive chemicals.

A key finding showed that to increase a polymer's chemical and temperature resistance, the cross-link density of the polymer needed to be increased. The 'tighter' the cross-linking (number of cross-links per unit of volume), the higher the resistance. However, the result of higher cross-linking was reduced flexibility and toughness, which meant a brittle polymer, hardly ideal for a tank coating on a constantly moving marine vessel stressed by movement on the high seas. (Note: an example of a high cross-linked, yet brittle polymer, is a phenolic, which usually fails, due to non-cross-linking of some of the hydroxal groups or entrapment of water which causes delamination of coating layers.)

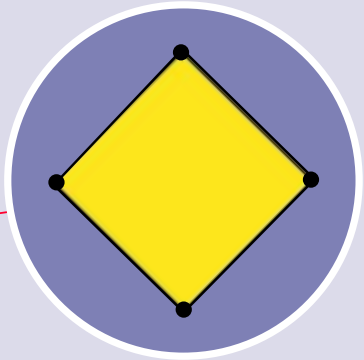
So this explains the basic chemistry and problems associated with coatings. Now we focus on how Advanced Polymer Coatings provides better coatings solutions, as shown below and on the next page.

Illustrating MarineLine® Higher Cross-Link Density

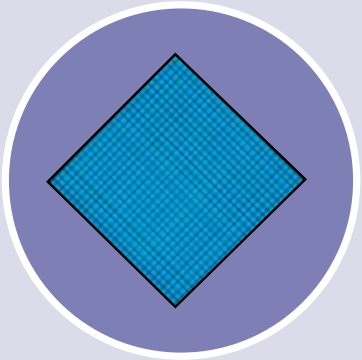
The greater the distance between the cross-links, the greater the permeation that leads to chemical attack and coating absorption. These illustrations represent the same size coating cutaway (left). The number of cross-links (depends on functionality), are shown per the same unit of volume. A much tighter screen is evident with MarineLine®.



Cutaway of a coating's surface.



Phenol Epoxy
Old technology
'open screen' structure
with 2 functionality
forms up to 4 cross-links
when cured.



MarineLine®
New technology
'closed screen' structure
with 28 functionality
forms up to 784 cross-links
when cured.

APC's Better Solution

The scientists at APC developed a way of cross-linking an organic polymer with an inorganic polymer with high multi-functional capability. The end result was a three-dimensional ladder-like structure where high cross-linking was achieved by the formation of Ether groups, C-O-C (carbon-oxygen-carbon), one of the strongest linkage bonds in chemistry. This technology eliminated high concentrations of hydroxyl groups (found in phenol epoxies) and precluded the formulation of ester groups which are subject to hydrolysis and acid attack.

The company then conducted more than 5,000 chemical and physical tests of this unique polymer system, and patented this development.

The next step in coatings development was to formulate this unique polymer into various protective coatings, that when heat-cured, achieved extremely high cross-linking, with a tough, flexible and ultra-smooth surface that could effectively withstand a wide range of chemicals with virtually no absorption of the cargo. These coating were shown to resist 98% of all corrosive acids, alkalis, solvents, gases and materials at various temperatures.

This breakthrough led to the marketing development of the MarineLine® brand and other protective coatings from APC. Shipowners were quick to pick up on the key benefits such as being able to carry the widest range of different chemicals versus all other tank coatings, enhance their ability to clean tanks quickly and easily switch to other cargoes, and to provide their customers with an assurance of cargo purity. Today more than 700 vessels have been coated with MarineLine®.

Leading independent agencies were also engaged to test MarineLine® for carrying a wide range of aggressive cargoes. They reported positive findings showing the higher and better performance capabilities of MarineLine® when compared to other coatings and in some instances, performing better than Stainless Steel.

APC continually strives to enhance the performance of its coatings with new advancements in higher elongation, lower surface energy for faster cleaning, and more eco-friendly formulations.

MarineLine®'s higher cross-link density translates into:

- Higher chemical resistance to acids, alkalis, and solvents
- Higher temperature resistance
- Higher resistance to absorption
- Higher toughness