(The work described in this paper was not funded by the U.S. Environmental Protection Agency. The contents do not necessarily reflect the views of th~ ~~~~~ and no official endorsement should be inferred.)

P-05726
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# Long Term Corrosion Protection with Single-Coat High-Ratio Zinc Silicate

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Today I will be talking about water-based zinc silicate, follow its evolution from the early 1940's to the present; the evolution from post-cure and self-cure products to the no-cure high-ratio, NASA formula that is available today.

Water-base zinc silicates were first developed back in the 1930's, but the first large commercial application was in 1942 on the Wyalla pipeline -- a 250-mile pipeline stretching from Wyalla to Morgan in Australia. The pipeline runs through the desert, through salt marshes and along the coast within a few yards of the ocean. After 48 years of exposure, a single 3 mil coat of water-base zinc silicate is still protecting the pipe with no sign of breakdown.

That first application of zinc silicate in 1942 had a unique curing process. The product was applied and then baked at about 450$^{O}$F to cure out the alkali metal that is present in all silicates. In the early 1950's, the product was brought to this country and a post-cure acid wash was developed to cure or neutralize the alkali.

(The following slides detail long term applications of post-cure and self-cure zinc silicates.)

In order to understand how any coating could protect steel permanently, it is important to understand the basic corrosion process on steel.

(The following is a discussion with slides, detailing the corrosion process on steel.)

There are three basic ways to stop corrosion:

1. With organic barrier coatings such as epoxy, urethane, acrylic, vinyl, etc. Barrier coatings adhere by means of a mechanical bond (vs a chemical bond) and because they are organic, break down over time.
2. By galvanizing or metalizing with pure zinc metal applied to the steel surface. A pure zinc coating protects by setting up a new anode/cathode relationship with the steel acting as the cathode and the zinc sacrificing as the anode. In mild environments this sacrificial method may last 40 years, however, in an extreme acid rain, road salt or marine environment, the zinc will sacrifice rapidly. When the zinc is depleted, corrosion will begin.

3. Or a third means of controlling corrosion is by applying a single coat of water-base zinc silicate. Both the above principles are at work with zinc silicate since it first acts galvanically or sacrifically and finally becomes a permanent barrier coating. Here's how it works:

Zinc silicate is 90 percent zinc and 10 percent silicate or liquid glass with the active componant being $SiO_2$ or silicone dioxide. $SiO_2$ has the unique capability to chemically complex with metal. The 90 percent zinc content initially sets up the same anode/ cathode relationship as in galvanizing but with one major difference. The zinc oxides formed by the sacrificing zinc continue to react with the $Si0_2$ while filling the pores in the porous film. Over time, the oxides form an extremely dense hard coating that ultimately seals off to become a permanent barrier coating. Why permanent? Because the backbone of the coating is ceramic, or glass ,or $Si0_2$, that is chemically bonded to the iron on the surface (over 2000 PSI). It does not break down over time.

(Many slides -- graphics and actual cross sections -- will be shown to illustrate all of the above; other slides will illustrate the self-healing properties of zinc silicates.)

So far, we have seen how generic zinc silicates protect steel and while all zinc silicates work in the same way, there has been a definite evolution in silicate chemistry that has allowed quality and production advantages.

In order to understand the evolution from low ratio post-cure and self-cure to high-ratio no-cure, you must understand the basic chemistry of alkali metal silicates. (Slides will aid in the following discussion.) Water-base zinc silicates are, very simply, silicate and zinc. And silicate is liquid glass. The question has been asked many times, "How is it possible to make glass into a liquid since glass is insoluble?" Chemically, $SiO_2$ and water will not react and might be illustrated by: $Si0_2 \parallel H_20$. However, if you will recall, early in this discussion I mentioned that $SiO_2$ reacts chemically with metal -- so if we can identify a metal that holds or reacts with water, we could bridge the $SiO_2$ and $H_2O$. The alkali metals, sodium (Na) potassium (K) and lithuim

(Li), do react with water and $SiO_2$. So an alkali metal silicate looks like this, $SiO_2$:$K_2O$:$H_20$ -- the potassium is holding the water and reacting with $SiO_2$ to form a stable liquid glass. That is as long as the ratio of $SiO_2$ to $K_2O$ does not go above 3.75:1.

After application of a standard ratio (3.75:1) zinc silicate, it's the alkali that must be cured out of the zinc silicate film. The solublizing agent must be removed by one of three curing methods: high temperature or baking, acid wash port-cure, or long term self-cure. It is this curing requirement that has kept water-base zinc silicates in a small niche market. In the early 1970's, NASA undertook a program to solve the curing problems and take advantage of the chemistry's permanent protection.

NASA found a way to raise the ratio from 3.75:1 up to 5.3:1 -- in other words, they found a way to remove the potassium metal before it goes in the pail, while maintaining the stability of the high-ratio liquid glass. So the curing process for high-ratio zinc silicate is simply evaporation of the water. As the water evaporates, the high-ratio film becomes insoluble and extremely hard and adhesive reaching 1000 PSI pull strength in just two hours.

The high-ratio chemistry now allows the easy application of a water-base zinc silicate without a post-cure or indeterminate, lengthy self-cure. Additional advantages include:

recoatable with itself for additional millage or easy repair;
self-inspecting over organic contamination;
mudcrack and overspray resistant up to 6-8 mils DFT;
topcoat with epoxy, acrylic, etc. in two hours or less;
zero VOC's, no fire hazard, no toxic chemical waste;
unbeatable economics, both short and long term.

(Following will be slides detailing long term and application case histories which illustrate the permanence and above advantages.)

The high-ratio zinc silicate NASA formula provides permanent protection with just a single coat. Permanent protection, coupled with the advantages above, offer short and long term economics that are beyond comparison with any coating chemistry that has come before. High-ratio zinc silicate chemistry is destined to become the world standard in corrosion protection for steel.