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INFO SHEET

Ultra-Weatherable Fluoropolymer Coatings for Bridges

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https://lumiflonusa.com/wp-content/uploads/2007_NYC_Bridge_Conf_Paper.pdf

ABSTRACT: Fluoropolymer coatings have been used on steel and concrete bridges for over 20 years. As a result of extensive laboratory testing and application success in the field, the Japanese Ministry of Land, Infrastructure, and Transport now requires the use of fluoropolymer topcoats on all bridges in Japan. The use of these topcoats should increase the effective life of bridge coating systems to at least 30 years, and sometimes to 60 years. This paper will discuss the general characteristics of fluoropolymer coatings, including results of accelerated and natural weathering tests, as well as corrosion resistance.

3.2. Corrosion Resistance of FEVE Based Coatings. While aesthetic considerations in selection of bridge coatings are increasing, the primary reason for coating application is to prevent corrosion or degradation of the substrate, whether it is steel or concrete.

Coating systems, not only topcoats, are used to prevent corrosion. On steel, a typical coating system consists of a zinc rich primer, an epoxy or urethane middle coat, and a topcoat. The topcoat and mid coat act to prevent corrosion by excluding contaminants that can initiate corrosion, like chloride or water. The zinc rich primer, while providing some barrier properties, works by setting up an electrical cell where the zinc is sacrificed preferentially to the steel.

The primer is meant to be the last resort in preventing corrosion. Some of these primers are estimated to last for 30 years or more. FEVE fluorourethane coatings assist in corrosion prevention due to their weathering properties. Because decomposition does not occur readily in FEVE coatings, practically the only decrease in coating thickness is due to physical removal by wind, rain, and other mechanical means. This means that even after years of exposure, FEVE coatings will lose less thickness, thus continuing to provide an effective barrier against corrosion initiators.

In contrast, other polymeric topcoats degrade over time to lower molecular weight materials which are easily removed by mechanical means. The removal of these materials exposes a fresh surface to UV light, setting up further degradation, and additional coating removal.

The durability of FEVE coatings has been demonstrated in extensive testing. The Ministry of Land, Transportation, and Infrastructure in Japan operates a marine test station 250 meters offshore in Suruga Bay, the deepest bay in Japan. The platform is used to provide a real time test platform for coatings for various types of exposure, **including immersion and tidal zone**. FEVE based fluoro urethane coatings were tested side by side with standard polyurethane coatings over a period of 16 years on this platform.

Each coating system consisted of an inorganic zinc rich primer (75µm), an epoxy middle coat (150 µm), and a topcoat (25 µm). Coated panels were evaluated at regular intervals for gloss and color retention, as well as changes in coating thickness.

During the first seven years of the test, the FEVE fluorourethane coating showed no change in thickness. For the next nine years, the FEVE based topcoat showed an average loss of 0.38 $\mu\text{m}/\text{year}$, for a total loss of 3.4 μm over the entire test period.

At this rate of change in thickness, the expected life of the fluorourethane topcoat would exceed 60 years.

Analysis of the coating system by Scanning Electron Microscopy (SEM) and Energy Dispersive X-Ray Microanalysis (EDX) indicated that no chloride had penetrated the FEVE based topcoat. No corrosion of the zinc rich primer was found, confirming that corrosion initiators had not reached the primer.

The urethane topcoat in contrast, lost about 2 $\mu\text{m}/\text{year}$ after the second year of exposure. The urethane topcoat was completely removed from the test coupon after 13 years.

One measure of corrosion is indicated by Electrochemical Impedance Spectroscopy (EIS). EIS involves sending alternating current between two electrodes, one a 3% saltwater solution, the other the metal panel. The coated side of the panel is exposed to the salt solution. The change in impedance at a constant frequency of 1 kHz is then measured.

The smaller the change in impedance, the better the corrosion protection offered by the coating system. In essence, the change in impedance can be related to the movement of corrosion initiators like chloride through the coating system. In the particular test, results of which are shown below in Figure 4, four coating systems were exposed for 1,000 hours in an accelerated weathering test. Then, the unscrubbed panels were subjected to 500 and 1,000 hours in the ASTM B-117 salt fog test, which is an accelerated test for corrosion.

Results indicate that the FEVE based coating system far outperforms competitive systems. Because the coatings were subjected to accelerated weathering and corrosion tests prior to use in the EIS test, the results indicate that the competitive topcoats suffered some degradation, and therefore were permeable to corrosion initiators.

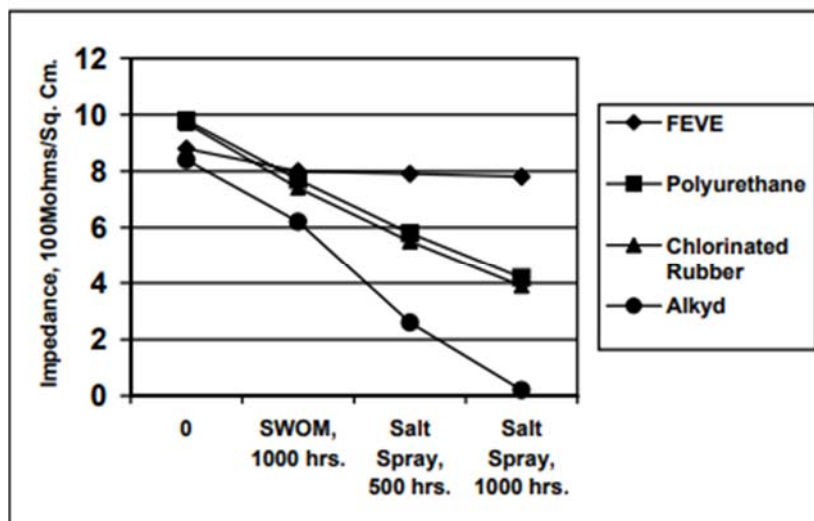


Figure 4. Electrochemical Impedance Spectroscopy Test Results for FEVE Based Coatings

Summary (by Chris Hitchins). These results show clearly the resistance of the FEVE based fluoropolymer coatings (PnF) to the effects of UV and saltwater attack over a decade and a half. Laboratory testing of the immersed and tideline panels shows a high level of performance already over 16 years and by extrapolation an effective life of around 60 years can be expected for the topcoat, in this aggressive marine environment.