

Public Abstract

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**Equivalent Circuit Modeling of TMS Plasma Polymer Coating Systems
on Cold-Rolled Steel**

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In an ongoing effort to replace phosphates in metal coatings, electrochemical impedance spectroscopy (EIS) during an accelerated corrosion (GM scab) test was used to differentiate between good and poor coating systems on cold-rolled steel (CRS). The best coating was determined to be a cathodic E-coat/trimethylsilane (TMS) plasma polymer/oxide-free steel surface having an impedance modulus at low frequency of 10^9 ohms throughout the entire corrosion test. A spray paint primer and surface oxides both contributed to a degradation of corrosion protection evident from a significant drop in impedance ($10^6 \Omega$).

With samples of known corrosion resistance, equivalent circuits were used to relate circuit elements to individual chemical processes taking place and identify the major factors contributing to failure of the coating. Two models (with and without plasma polymer film) were proposed and a good correlation to the EIS data was shown by a good visual plot fit and low chi squared values ($<10^{-3}$).

It was determined that the performance of the plasma polymer and conditions at the PP/steel interface are the major factors influencing the coating performance. The good coating system maintained a low double layer capacitance (10^{-9} F) and high charge transfer resistance ($10^9 \Omega$) relating to good adhesion at the coating/metal interface. The other samples, which exhibited poor adhesion, had a much higher capacitance (10^{-6} F) meaning pool formation has created a water/metal interface. This in turn allows salt penetration for a higher corrosion rate showing up in the lower resistance ($10^6 \Omega$).