

Corrosion Simulation Tests: Analysis and Improvement of Corrosion Resistance for Automotive Components

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ABSTRACT

Corrosion testing and simulation has played a critical role in the development of corrosion resistant automobiles. Much has been learned over a period of time with respect to the automotive corrosion protection and its assessment. A range of coatings and platings are being used in the automotive sector. In this field of application, designs are very complex and focus is on enhanced vehicle level corrosion protection, given the high corrosion warranty costs.

The objective of the present study was to develop an electrochemical test method to rapidly and quantitatively screen the corrosion performance of automotive coating systems. The present study compares electrochemical results obtained using a linear polarization resistance (LPR) to results obtained via the standard ASTM B117 salt spray test. Salt spray tests were done on a separate series of these coating systems according to ASTM B117, and the results were ranked from 10 (excellent performance) to 1 (very poor performance). Comparison between electrochemical test and the salt spray rankings of the samples suggests a promising correlation between the corrosion rate data and salt spray performance, although additional information is needed to confirm this hypothesis. However, kinetic information that examines the rate of corrosion as a function of time following the introduction of other parameters like welding, sealants over the coating is essential in predicting performance.

KEYWORDS: Coatings, Plating, Electrochemical tests, Salt spray ranking

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INTRODUCTION

Corrosion protection properties of coatings and plating systems can be evaluated via a number of approaches: outdoor exposure, accelerated laboratory tests, electrochemical measurement techniques for early detection, as well as combinations of accelerated tests and electrochemical test methods. One of the main objectives of these tests from a manufacturing standpoint is to reliably forecast the service life and performance characteristics of a coating/ plating in a short period of time. However, a method that can accurately quantify and rapidly screen the corrosion protection of a series of coatings relative to each other is also desirable. The need for such a screening procedure is accentuated by the rapid development of new coating formulations. Thus, desirable coating test attributes include reliability, sensitivity (i.e., ability to discriminate), and speed. Outdoor exposure is assumed to provide the most reliable indicator of service performance but has drawbacks of long testing times.

CORROSION CAUSES IN AUTOMOBILES

Amongst several causes that lead to various types of auto corrosion, the prominent ones are design process, manufacturing process and the operating conditions.

Design Process

Designers make an assortment of choices that influence how susceptible a vehicle may be to corrosion. During design stage, care shall be taken to reduce dissimilar metal contacts, crevices, stresses, poor drainage and areas where dirt, mud and salt can build up. Choice of materials in the design shall also largely influence the corrosion behavior. Use of corrosion-resistant metals, coated steels, nonferrous materials, polymers, composites as well as avoidance of dissimilar metal contact can help enhance vehicle life.

A critical consideration in the design process that affects corrosion performance involves choice of primers, paints, sealers & waxes. Use of corrosion resistant primers over the

entire body and special chip-resistant coatings for the underbody parts help to delay onset of corrosion.

Manufacturing Process

Measures addressed in the design phase could be rendered useless if the manufacturing quality is inferior. Quality of welding, surface pre-treatment, application techniques of coatings, sealants, waxes etc. reflect the quality of vehicle corrosion protection.

Operating Conditions

Corrosivity of local environment shall strongly affect the corrosion performance of the vehicle. Under such conditions, personal driving habits & efficient vehicle maintenance such as regular washing and replacement of fluids can also to large extent delay corrosion [1].

ASSEMBLY COATINGS FOR CORROSION PROTECTION

A variety of coatings such as zinc rich primers, waxes, sealants are recommended to be applied after fabrication & during assembly to provide supplemental corrosion protection of vehicles. Principle in most cases is to exclude the corrosive environment from the substrate - barrier type.

Zinc-rich spray primer recommended for application on joints & interior surfaces post fabrication & prior to assembly.

Weld-through coatings developed as an alternative material to the zinc-rich spray paint and provide good protection even when applied to oily steel substrates.

Corrosion-preventive wax, applied after painting, provides additional barrier corrosion protection in body cavities, seams & hem areas.

Chip-resistant coatings applied on the vehicle underbody to protect against stone chipping & road blast [2].

CORROSION TESTING AND VALIDATION

Test methods for determining corrosion resistance are specific and must be based on the conditions prevailing and the materials to be used, including coatings and other protective measures planned for the specific application. A large number of factors affect corrosion behavior, and therefore there is no universal corrosion test. The most reliable indication of corrosion behavior is service history. However, that information is rarely available exactly as needed, and therefore other tests are required, ranging from simple electrochemical tests to highly accelerated laboratory tests. It is the need to obtain information beyond the service history that introduces ambiguity into corrosion testing [3].

a. Comparison of Electrochemical Test to Salt Spray Test

Electrochemical results obtained using a linear polarization resistance (LPR) to results obtained via the standard ASTM B117 salt spray test. Salt spray tests were done on a separate series of these coating systems according to ASTM B117, and the results were ranked from 10 (excellent performance) to 1 (very poor performance).

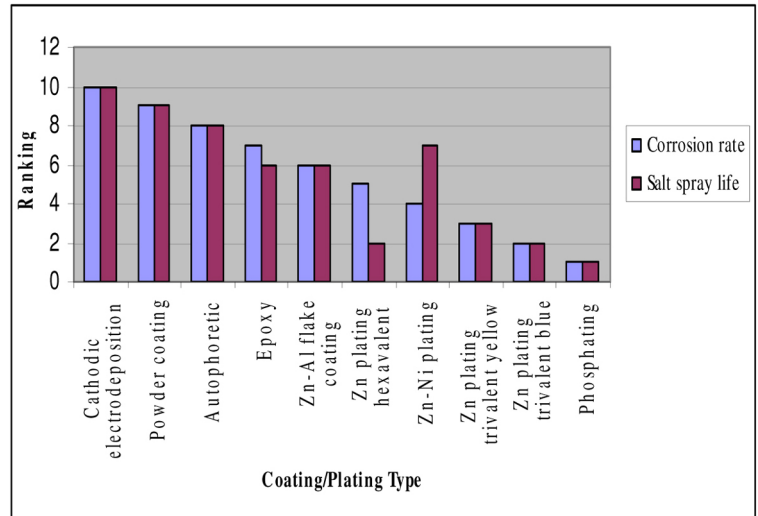


Figure 1. Comparison of various coatings and platings

b. Laboratory Tests

Though the comparison between electrochemical test and the salt spray rankings of the samples suggests promising correlation additional information is needed to confirm this hypothesis. However, kinetic information that examines the rate of corrosion as a function of time following the introduction of other parameters like welding, sealants over the coating is essential in predicting the performance.

Accelerated corrosion tests on components are planned in such a way that they represent the assemblies as in the production vehicle. Behavior of aggregates designed to replicate vehicle joineries with sealants, waxes, tack welds, seam welds, spot welds, brazing joints, bolted joints, hemming, stitching, clinching etc., assembled and treated further as in a vehicle. Fasteners with various surface protection and topcoats are subjected to accelerated testing in assembled condition, torque and without torque.

BIW joints and fasteners (as indicated in [tables 1 & 2](#)) are subjected to Neutral salt spray and cyclic corrosion tests simultaneously. Additionally, the underbody structural parts are subjected to gravel exposure to aggravate and exactly replicate the actual running conditions.