CYCLIC CABINET CORROSION TESTING

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EDITOR

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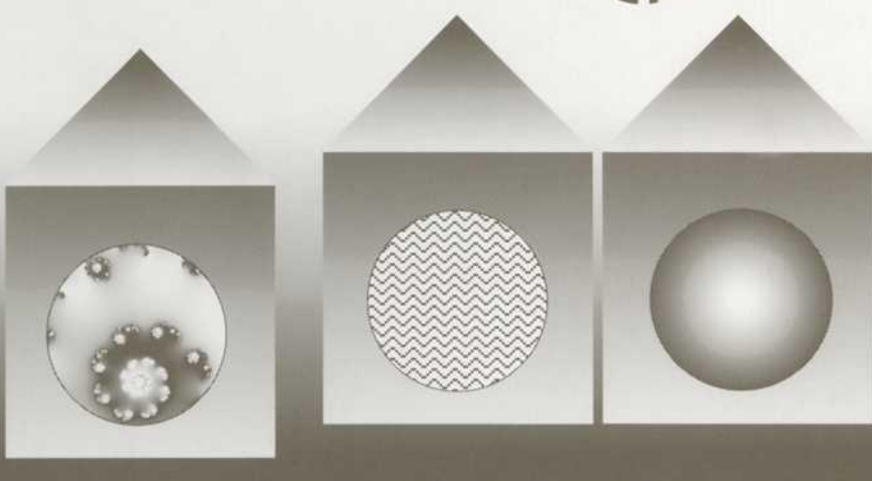

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Peer Review Policy

Each paper published in this volume was evaluated by three peer reviewers. The authors addressed all of the reviewers' comments to the satisfaction of both the technical editors and the ASTM Committee on Publications.

To make technical information available as quickly as possible, the peer-reviewed papers in this publication were prepared "camera-ready" as submitted by the authors.

The quality of the papers in this publication reflects not only the obvious efforts of the authors and the technical editors, but also the work of these peer reviewers. The ASTM Committee on Publications acknowledges with appreciation their dedication and contribution to time and effort on behalf of ASTM.

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Foreword

This publication, *Cyclic Cabinet Corrosion Testing*, contains papers presented at the symposium of the same name held in Dallas/Fort Worth Airport, TX on 14–19 November 1993. The symposium was sponsored by ASTM Committee G-1 on Corrosion of Metals. Gardner S. Haynes of Texas Instruments, Inc. in Attleboro, TX presided as Chairman and is the editor of the resulting publication.

Contents

Overview

The oldest and most widely used standardized corrosion test is the salt spray test (ASTM Test Method of Salt Spray (Fog) Testing, B 117). The history of the salt spray test has been documented in research reports by McMaster and Ketcham which are available from ASTM (RR: G01-1003, Background Information for B 117, Salt Spray (Fog) Testing). Over the years many modifications have been made to this test. The purpose of these changes was to produce more reproducible and realistic results, however, as stated in the standard "there is usually not a direct relation between salt spray resistance and resistance to corrosion in other media." Since conventional salt spray testing seldom correlates with actual performance in service, a variety of cyclic cabinet tests have been developed to predict corrosion resistance. The purpose of the symposium that forms the basis of this STP was to promote understanding of cyclic cabinet corrosion tests and other alternatives to the salt spray test. The goal was to establish correlations between these tests and actual corrosion resistance in service environments and to promote standardization of these tests.

This STP clearly documents the failure of the salt spray test to predict actual service performance in a number of environments. It contains fundamental information on corrosion mechanisms in accelerated tests and service environments and provides guidance on determining acceleration factors with appropriate corrosion mechanisms. A number of alternative test procedures are described and correlated with service performance. The use of cyclic cabinet corrosion tests for determining the comparative corrosion resistance of a range of materials is a unifying theme.

The group of papers published in this volume has been divided into three sections. Obviously this necessitates arbitrary placement of papers that could fit into more than one section. The sections are (1) testing principles, (2) tests for automotive environments, and (3) tests for simulating atmospheric environments.

Testing Principles

The section on testing principles contains the papers that deal with mechanisms of corrosion in cyclic cabinet tests and the fundamental testing principles related to these mechanisms. The paper by Lyon et. al. describes a cyclic wet-dry procedure using an artificial acid rain solution. This test.does not produce the blistering that occurs in the salt spray test of coated galvanized steel while retaining significant discrimination to edge and scratch disbonding. They also discuss the subjective nature of current assessment criteria and provide suggestions on objective methods that could be standardized. They found that their cyclic procedure reproduces the type of degradation fo coil coated roofing products that occurs under natural weathering. The review paper by Roberge examines the inadequacies of the salt spray test in the light of a comprehensive framework of parameters leading to corrosion degradation. He highlights the importance of competing failure modes and the statistical characteristics of the underlying acceleration factors. Using data published previously, he points out the lack of correlation between the salt spray test and marine exposure and the better correlation of some electrochemical techniques with seawater exposure. The importance of applying statistical methods and experimental design methodologies to obtain better models for the prediction of lifetime performance are discussed. Singh and Cordo use statistical techniques to rank order the corrosivity of seven different cyclic corrosion tests toward coated steel. They found that cyclic salt fog and cyclic salt spray tests produced the fastest corrosion growth but were concerned with the subjective nature of corrosion evaluation. There is still a need to provide a correlation between actual service performance and results from these tests. The final two papers in this section could also have been placed in the section on tests for simulating atmospheric environments. In his paper on testing of thermal spray coatings Bowers describes a cyclic wear-corrosion test capable of predicting performance in Yankee dryers. The test was found to reproduce the sliding wear mechanism responsible for degradation of coatings in this environment. He used surface profilometer and microscopic methods to evaluate material-environment interactions. The final paper by Roberge describes an electrochemical technique for quality control of aluminum anodizing that can be used instead of salt spray testing. Time to failure of anodized aluminum panels in the salt spray test was found to be proportional to corrosion rates determined by potentiodynamic polarization. Statistical analysis showed that both methods revealed defective test panels. The advantage of the 10-min electrochemical method was its ability to be used for better process control compared to a 336 h salt spray test.

Tests for Automotive Environments

An exhaustive study conducted by Advanced International Studies Institute (AISI) and Society of Automotive Engineers (SAE) to correlate describe creep corrosion resistance in cyclic cabinet tests with on-vehicle performance is described in the paper by Roudabush, McCune and Townsend. The goal of this work is the development of an accelerated laboratory test for ranking the cosmetic corrosion resistance of automotive steel sheet products. Detailed statistical analysis of the results for ten different materials in cyclic cabinet tests, proving ground tests, outdoor exposure and on-vehicle exposure is presented. The comparative ranking of the various cyclic tests is listed and future work of this group is discussed. Moran et. al. describe a parallel effort to correlate the performance of painted aluminum automotive body sheet in cyclic cabinet tests with performance on vehicles. They describe an improved method for quantifying cosmetic corrosion of painted aluminum. There was no correlation between the peformance of painted aluminum and painted steel in their tests. Quite surprisingly they found that the best method for painted aluminum was continuous salt spray. They also discuss the influence of alloy composition and zinc phosphate coating weight on test results. Suga and Suga present the efforts of the Japanese Society of Automotive Engineers to define a cyclic cabinet corrosion test for painted steel. They correlated performance of a matrix of coated and uncoated bare and painted sheet steel in cyclic tests with outdoor exposure. Results indicated that time of wetness was a critical variable. Their standard test (JASO M 609) is described. Additional work to develop a cyclic cabinet test to simulate the effects of acid rain and acid rain with artificial light is also described.

Tests for Simulating Atmospheric Environments

The performance of coated and uncoated aluminum alloys for heat exchanger applications was evaluated by Lifka and Vandenburg in salt spray (ASTM B 117), alternate immersion in a synthetic condensate and acidified cyclic salt spray. The acidified cyclic salt spray (ASTM Practice for Modified Salt Spray Fog Testing, G 85-A2) identified the most resistant coatings after 3 weeks exposure while the other tests provided poorer discrimination after significantly longer exposure periods. They were also able to predict performance of complete assemblies containing multiple metals by testing only fin-stock in this test. Zhang and Tran used a cyclic test consisting of solution spraying, water condensation, and air drying to study corrosion rates and corrosion products on zinc and steel. The wetting and drying patterns affected not only the corrosion rates but also the morphology of corrosion products. They found that the corrosion product formed on zinc under cyclic conditions is distinctively localized and retards corrosion while that formed on steel is more uniform and has a less retarding effect. They suggest that the cyclic wetting and drying pattern may explain the differences in corrosion rates of metals in different geographic locations.

The papers briefly described here should provide the reader with much of the latest information on cyclic cabinet testing. Many combinations of test conditions have been evaluated for a variety of environments. The ability of a particular test to predict corrosion performance has been found to be material and environment specific. This volume provides some guidance on choosing an appropriate test and evaluating the results. The symposium chairman gratefully acknowledges the efforts of the authors, reviewers, and ASTM staff that have made this publication possible.

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