



**NEW METHODS FOR
CORROSION
TESTING OF
ALUMINUM
ALLOYS**

AGARWALA / UGIANSKY

EDITORS

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New Methods for Corrosion Testing of Aluminum Alloys

Vinod S. Agarwala and Gilbert M. Ugiansky, editors

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Foreword

This publication, *New Methods for Corrosion Testing of Aluminum Alloys*, contains papers presented at the International Symposium on Corrosion Testing of Aluminum Alloys, which was held in San Francisco, California, on 21–22 May 1990. The symposium was sponsored by ASTM Committee G-1 on Corrosion of Metals. The chairmen of the symposium were Vinod S. Agarwala, Naval Air Development Center, and Gilbert M. Ugiansky, Ugiansky and Company, both of whom also served as editors of this publication.

Contents

Overview	vii
Modification of the EXCO Test Method for Exfoliation Corrosion Susceptibility in 7XXX, 2XXX, and Aluminum-Lithium Alloys—SOOTAE LEE AND BERNARD W. LIFKA	1
Materials Evaluation Using Wet-Dry Mixed Salt-Spray Tests—STUART B. LYON, GEORGE E. THOMPSON, AND J. BRIAN JOHNSON	20
A Comparison of Potentiodynamic Polarization Tests with Wet-Dry Mixed Salt-Spray Testing of Aluminum-Magnesium-Silicon Alloy—S. V. BAKER, S. B. LYON, G. E. THOMPSON, G. C. WOOD, AND K. G. LEWIS	32
Accelerated Test for Determining Microbiological-Influenced Corrosion Resistance of Aluminum Alloys—B. M. ROSALES, E. S. AYLLON, AND M. C. LEIRO	50
Corrosion of Aluminum and Aluminum Alloys in Nitric Acid—ELMAR-MANFRED HORN AND HELMUT W. DIEKMANN	60
Exfoliation Corrosion Testing of Aluminum-Lithium Alloys—JAMES J. THOMPSON	70
The Breaking Load Method: Results and Statistical Modification from the ASTM Interlaboratory Test Program—E. L. COLVIN AND M. R. EMPTAGE	82
Damage-Based Assessment of Stress Corrosion Performances Among Aluminum Alloys—D. A. LUKASAK, R. J. BUCCI, E. L. COLVIN, AND B. W. LIFKA	101
Corrosion Fatigue Crack Growth Rate of Aluminum-Lithium Alloy Sheet and Its Weldment—CHARLES S. LIN AND WILLIAM E. KRAMS	117
Potentiometric and Potentiostatic Determination of the Corrosion Rate of Welded 2519 Aluminum Alloy—CARLO B. SONNINO, TOM FORD, AND VIRGINIA VANARK	132
Detection and Monitoring of Localized Corrosion of Aluminum Alloys with Electrochemical Impedance Spectroscopy—FLORIAN MANSFELD, S. LIN, AND HONG SHIH	141
Time-Lapse Video Techniques in the Corrosion Testing of Aluminum Alloys—C. J. NEWTON AND N. J. H. HOLROYD	153
Passivation in Rare Earth Metal Chlorides—A New Conversion Coating Process for Aluminum Alloys—HONG SHIH AND FLORIAN MANSFELD	180

Examination of the Influence of Lithium on the Repassivation Rate of Aluminum Alloys—M. R. STOUDT, A. K. VASUDEVAN, AND R. E. RICKER	196
Author Index	215
Subject Index	217

Overview

ASTM test standards represent a consensus of the best currently available test procedures, supported by experience and adequate data from cooperative testing. From time to time, they must be revised or substituted in order to keep abreast with technological advances in the development of materials and in their applications. Often, the procedures for testing materials outgrow their usefulness in a particular industry and thus become obsolete. ASTM Special Technical Publications (STPs) are among the best means of disseminating the new information to the world community for acceptance and for later adoption in new standards.

In recent years, aluminum alloys have been given an even greater role as materials of construction in both the military and private sectors. This is primarily due to their unique combination of useful properties such as low density, high strength, general corrosion resistance, and reasonable cost. Over the decades, the demand for low-density materials in the aerospace industry has led to the development of several new and highly exotic aluminum alloys. Their potential utilization has not yet been fully realized because of limitations in satisfying the consumer's needs. The probable cause has been that the current standard methods for testing such materials for corrosion and corrosion-assisted cracking resistance could not satisfy everyone—the manufacturer, the fabricator/designer, and the consumer—because the results of testing vary with the service conditions.

In the past, most methods were not industry oriented but rather environment oriented; hence, material qualifications tests were performed based on the standards that were available, and the consumer had to be satisfied with a conservative approach. Now, technological advances have changed this classical approach, and consumers have begun to seek out more precise and tailor-made procedures for applications. In addition, the materials of today are being subjected to highly diversified service conditions, from pristine (rural) to highly corrosive (aircraft carrier) environments. The utilization of aluminum alloys today has become very industry-specific; therefore, the qualification tests used must address these specific requirements. Often, corrosion testing requirements do exceed the material's performance requirements; however, as the materials are better selected and designed based on their particular usage, the necessity for corrosion testing also has become selective. Thus, the advent of new materials and the extent to which they will be used have posed new questions as to whether the existing standards can be adapted or new tests are mandated. In particular, Al-Li, Al-Li-X, and Al-Fe-X alloys and aluminum metal/matrix composites have found applications in industry for which there are as yet no standard test methods available.

The papers published in this STP, *New Methods for Corrosion Testing of Aluminum Alloys*, were presented at the International Symposium on Corrosion Testing of Aluminum Alloys. This symposium was the outcome of a workshop on exfoliation corrosion which was organized to discuss the usefulness of various current standards on exfoliation and corrosion testing and their applicability to current requirements and new advanced aluminum alloys. The objective of the workshop was to determine whether the existing standards should be revised or adapted to new alloys or if new tests were needed. The following existing ASTM standards were discussed in detail with pros and cons: the ASTM Test for Exfoliation Corrosion

Susceptibility in 2XXX and 7XXX Series Aluminum Alloys (EXCO Test) (G 34-86), the ASTM Method for Visual Assessment of Exfoliation Corrosion Susceptibility of 5XXX Series Aluminum Alloys (Asset Test) (G 66-86), and the ASTM Method for Determining the Susceptibility to Intergranular Corrosion of 5XXX Series Aluminum Alloys by Mass Loss After Exposure to Nitric Acid (NAMLT Test) (G 67-86). The outcome of the workshop was the motivation for further action and, thus, the organization of this international symposium.

Typically, the well-documented forms of corrosion for aluminum alloys are localized and exfoliation (intergranular) corrosion; often these two forms lead to severe damage, such as stress corrosion cracking and corrosion fatigue. Under high-strength conditions, most aluminum alloys are generally highly susceptible to exfoliation (intergranular) corrosion and stress corrosion cracking in saltwater environments. Since most aluminum alloys used as structural materials require high strength, their susceptibility to stress corrosion cracking is of great concern. The papers related to the breaking load technique have provided a new and more quantitative approach to evaluating and rating the stress corrosion cracking performances of aluminum alloys. It has been claimed that the test is more discriminating than any other accelerated laboratory practice known for distinguishing the stress corrosion cracking resistance of materials with relatively close resistance levels.

The workshop on exfoliation testing standards presented diverse points of view from various segments of industry and government, and its findings suggested that the current ASTM methods are not up to date or adequate for some service conditions. For example, the EXCO test was found satisfactory for 7075-T6 aluminum alloy in relation to the needs of the U.S. Department of the Navy for aircraft carrier environments. It, however, failed to be relevant when new, more exotic alloys, such as Al-Li-X alloys, were tested. It has been shown that these alloys corrode differently as they alter the chemistry of the test medium during exposure. Even in the case of conventional alloys, it has been suggested that, in a comparison of the (EXCO) test results with 2 to 5-year seacoast atmospheric exposure tests on T6 and T7-type tempers of several 7XXX aluminum alloys, the EXCO test overestimated the exfoliation damage observed. In addition, the variability of the differences between the accelerated rating and the atmospheric test rating was substantial. It was also claimed that the EXCO test does not always make distinctions between the 7XXX alloys in the three commercial tempers T6, T76, T74. A modified EXCO test method has been presented which controls the bath chemistry fairly well during exposure and, therefore, may offer better differentiation between the different levels of exfoliation resistances.

Similarly, when it comes to the testing of new materials, MASTMAASIS tests (ASTM Standard G 85. A2-85) fail to adapt, and contrasting observations have been reported for 2091 Al-Li alloy, in which the dry bottom testing showed more severe corrosion than the wet bottom testing. However, the MASTMAASIS and sulfur dioxide salt spray testing for three to four weeks and the EXCO tests produced behaviors similar to shipboard exposure for 7075 aluminum. For Al-Li-X alloys, the accelerated laboratory tests did not reproduce shipboard exposure results. Since several major aluminum producers are attempting to commercialize aluminum-lithium alloys as replacements for existing high-strength aluminum alloys in aerospace applications, a need to develop an accelerated test method exists.

Several new approaches to monitoring corrosion have been presented. The *in-situ* time-lapse video techniques, the electrochemical impedance spectroscopy for localized or hidden corrosion, and the electrochemical polarization method for localized corrosion due to microbial effects provide some new advances in aluminum alloy testing. The shortcomings of the ASTM Method of Salt Spray (Fog) Testing (B 117-90) were reevaluated in light of the changing service environment, and an alternative has been proposed which may provide a better simulation of the testing conditions. A mixed-salt solution containing ammonium

sulfate and sodium chloride with a 1-h dry cycle has been claimed to be better than the continuous NaCl spray.

The editors believe that this Special Technical Publication may provide avenues for modifying current standards and for developing new standards for testing for ASTM and, most importantly, for the technical community for their use and understanding. ASTM Subcommittee G01.05 on Laboratory Corrosion Tests, a subcommittee of ASTM Committee G-1 on Corrosion of Metals, gratefully acknowledges the contributions of the authors, members of the review board, and the publications personnel of ASTM.

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