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REPORT NO. NAEC-AML-1819

INVESTIGATION OF ANTIMONY COATINGS,
CYCLIC OXIDATION-CORROSION ENVIRONMENT

FINAL REPORT

PROBLEM ASSIGNMENT NO. C 12 RMA 42-52 UNDER BUREAU OF NAVAL WEAPONS WEPTASK RRMA 05 010/200 1/R007 08 01

A. INTRODUCTION

Magnesium, when coupled to steel, corrodes at an extremely rapid rate in a marine environment. Cadmium, tin, aluminum and antimony electrodeposits on the steel reduce the corrosion rate in varying degrees. In addition, paints have been used with various degrees of success.

A study was made of the protective properties of antimony when plated on steel and coupled to magnesium with and without supplementary paint systems (reference (a)). This study indicated that antimony plated systems were inferior to tin plated systems and painted systems as well.

Inasmuch as tin cannot be used at temperatures of 600°F due to dangers from stress alloying, it was thought that antimony might be useful as a coating on steel for those elevated temperature applications involving couples of steel and magnesium. Although aluminum is excellent for the oxidation protection of steel, antimony was thought to be more effective in preventing galvanic action when coupled to magnesium.

B. TEST METHODS AND RESULTS

1. Panel Preparation

Magnesium alloy panels, 3"x8"x.250", and 4130 steel cleats, 2"x3"x.125", were drilled to accept 56S "universal head" rivets. The steel cleats were plated with either antimony from a citrate bath or aluminum by the "Ethyl" process. The thicknesses of both were .001". Each magnesium panel and each steel cleat were weighed separately and the assemblies were then riveted together.

2. Oxidation-Corrosion Resistance

These panels were exposed at 600°F for 16 hours followed by 32 hours in 15° racks in a 5% salt spray cabinet. After each cycle they were removed for observation and photographing.

Results of these tests are shown in Plates 1 and 2. A discussion of these results follows:

After the elevated temperature exposure, the panels showed little difference, except for the oxidation of the unplated steel cleats used as a control. However, upon removal from the salt spray, the antimony plated cleats appeared to be protecting the magnesium somewhat better than the aluminum ones. After the second cycle, these observations were more vividly supported. Most of the corrosion was adjacent to the cleat and extended about .250" with a depth of about .060". The panels having the aluminum plated cleats were somewhat more deeply corroded and the aluminum was missing from part of the surface and all of the edges.

In contrast, the antimony was intact, no corrosion of the steel was observed and only the magnesium panels were corroded.

However, when the cleats were separated from the panels, large amounts of corrosion products were found underneath and the magnesium panels which held the antimony plated cleats had about 85 percent of this surface corroded. The panels having the aluminum plated cleat were only about 60 percent corroded under the cleat.

After cleaning off the corrosion products, weight loss measurements showed the following:

COUPLE	MAGNESIUM WT. LOSS	AV.	% CORRODED Based on steel as 100%
Steel and Magnesium	2.34 g.	2.17	100.0
Steel and Magnesium	2.01 g.		
Sb plated Steel and Magnesium	1.13 g.	1.35	62.2
Sb plated Steel and Magnesium	1.58 g.		
Al plated Steel and Magnesium	1.29 g.	1.14	52.6
Al plated Steel and Magnesium	.99 g.		

NOTE: No significant differences in wt. loss were observed for the steel cleats.

This information clearly shows that the aluminum plated panels were more protective than the antimony, although the difference was not great enough to guarantee the safe use of this system. However, it is believed that an aluminum coating on steel with lower porosity may result in improved protection for this application.

C. CONCLUSIONS

Based on the work completed, it is concluded that:

1. The protection afforded by "Ethyl" aluminum coatings on steel coupled to magnesium is slightly better than antimony coatings produced from a citrate bath, in a cyclical oxidation-corrosion environment.

2. Lower porosity of the aluminum on steel may result in greatly improved protection for this application.

D. RECOMMENDATIONS

The use of antimony plated steel is not recommended for elevated temperature applications involving steel-magnesium couples.

The better performance of the aluminum coatings versus antimony coatings for the corrosion protection of steel-magnesium couples at elevated temperatures warrants further investigation.

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Ref: (a) NAVAIRENGCEN Report No. NAEC-AML-1675 of 28 May 1963

PLATES:

1 - Effect of Antimony and Aluminum Plating on the Oxidation-Corrosion Resistance of Magnesium-Steel Couples - 2 Cycles of Exposure

2 - Comparison of Oxidation-Corrosion Damage of Magnesium Coupled to Steel

Aluminum Plated Steel Cleat

Antimony Plated Steel Cleat

Bare Steel Cleat

EFFECT OF ANTIMONY AND ALUMINUM PLATING ON THE OXIDATION - CORROSION RESISTANCE OF MAGNESIUM - STEEL COUPLES

2 Cycles of Exposure

PHOTO NO: CAN-355581(L)-10-63

Exposed Side Underside
of
Aluminum Plated
Steel Cleat

Exposed Side Underside
of
Antimony Plated
Steel Cleat

Exposed Side Underside
of
Bare Steel
Cleat

COMPARISON OF OXIDATION - CORROSION DAMAGE OF MAGNESIUM COUPLED TO STEEL

PHOTO NO: CAN-355582(L)-10-63