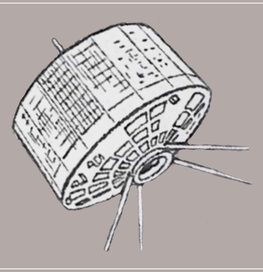

Tough Love for Magnesium

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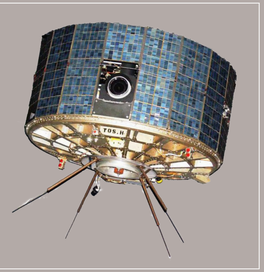
Emil Buehler Conservation Laboratory, Smithsonian National Air and Space Museum (NASM)



INTRODUCTION

Magnesium alloys have a unique advantage as structural metals since they are both lightweight and strong. For these reasons, they have extensive industrial applications, particularly in aerospace engineering. While magnesium is used across various industries, it is reactive and highly susceptible to corrosion, particularly in the presence of humidity and contact with dissimilar metals.

In order to deter corrosion on magnesium, a conversion coating is typically applied. The conversion coating process changes the surface of the metal into a more stable non-metallic compound. Since the 1920's, chromates have been commonly used to create conversion coatings on magnesium alloys. Unfortunately, many of these chemicals contain toxic hexavalent chromium which is carcinogenic.

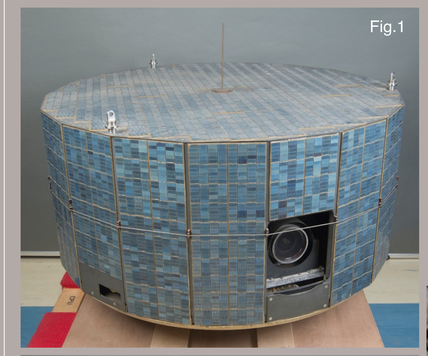


Fig.1

TIROS H (1964-65), a weather satellite, came into the lab for treatment (Fig. 1) and after an initial disassembly (Fig. 2), the satellite was found to have extensive magnesium corrosion on the majority of the internal components, including the two television cameras (Fig. 3-4).

The magnesium components still had some of the original conversion coating remaining. This coating has a gold or brassy appearance covering the silvery white magnesium metal beneath.

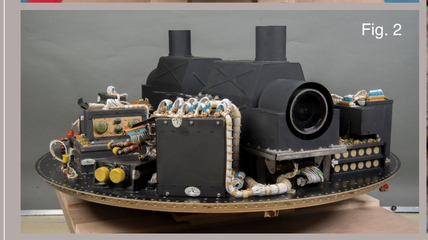


Fig. 2


Fig. 3

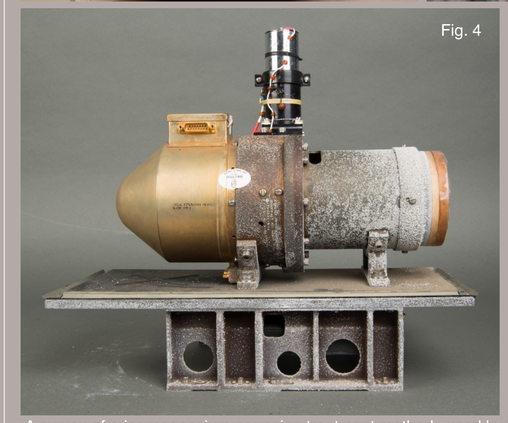


Fig. 4

Figure 1. TIROS H before disassembly
Figure 2. TIROS H during disassembly
Figure 3. Photomicrograph of magnesium corrosion on the camera at x100 magnification
Figure 4. Detached camera with magnesium corrosion around the lens and base components

A survey of prior magnesium corrosion treatment methods used by NASM conservation and restoration departments was conducted and prompted a need for alternative solutions. We investigated the latest advancements in corrosion control being utilized by industry.

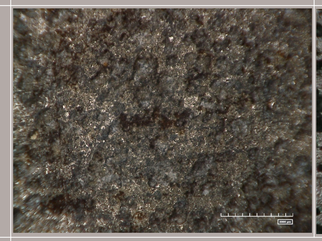
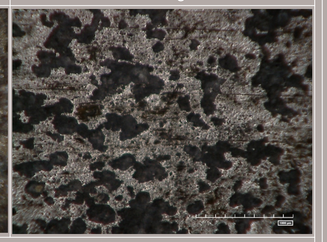
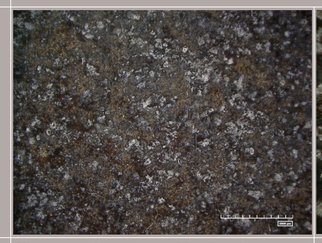
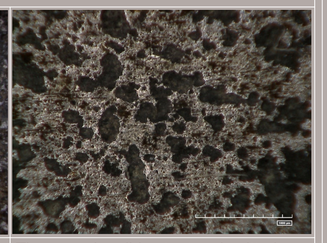
Criteria for choosing industrial products:

- Safe alternative to toxic chromate conversion coatings
- Effective in removing active corrosion and providing lasting corrosion protection to magnesium
- Mild enough to not disturb the original conversion coating so as to preserve as much original material as possible
- Transparent and colorless, the new conversion coating should be sympathetic to the losses and not impart a new color

Ultimately, we chose to use Sanchem's 560RTU mild acid cleaner and Sanchem's SafeGard CC 13062Mg RTU conversion coating.

EXPERIMENT

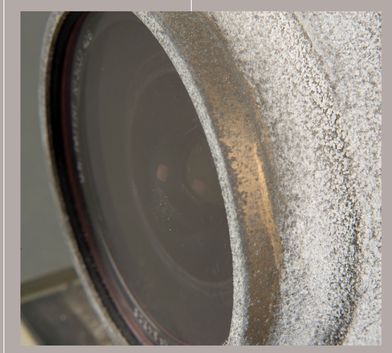
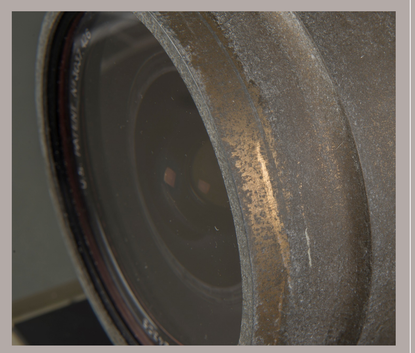
In order to test the efficacy of the Sanchem process compared with simple mechanical cleaning, we undertook the following experiment*:

	Coupon 1	Coupon 2
Preparation	Media blasting with crushed walnut shells	Media blasting, acid cleaning with Sanchem's 560RTU followed by water rinse and an application of Sanchem's SafeGard CC 13062Mg RTU
Photomicrograph before test, x35		
Test parameters	Both coupons were placed in a humidity chamber for 48 hours	
Photomicrograph after test, x35		
Observations	The corrosion returned in pitted areas	The corrosion did not return in pitted areas

*In both cases the test coupons did not receive a coating over the conversion coating.

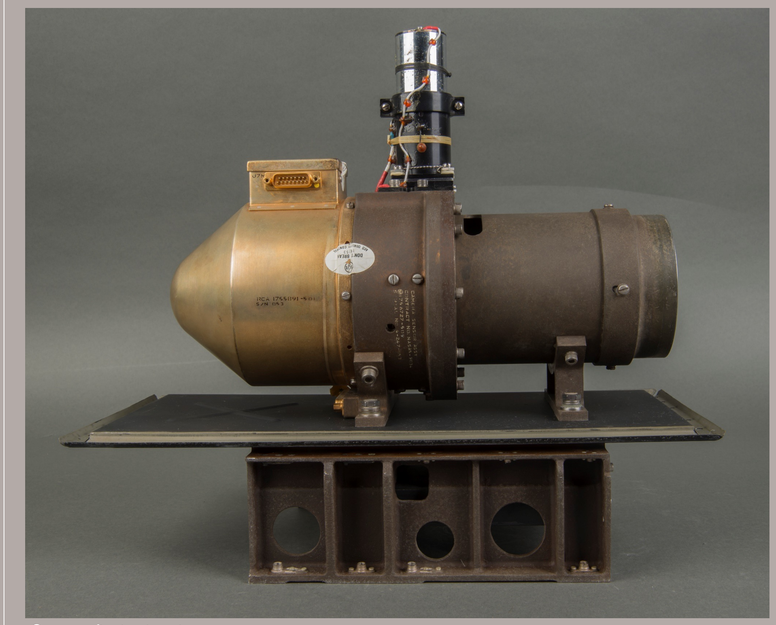
TREATMENT

Disassembly	Where possible, all elements with magnesium were removed from the object for treatment
Media Blasting	Mechanical cleaning using crushed walnut shells in a media blast cabinet
Acid Cleaning	Sanchem's 560RTU (glycolic acid cleaner) When practical, the components were immersed for 2 minutes and a non-woven abrasive pad was used to enhance the corrosion reduction process. In all other cases, the acid cleaner was applied directly with the pad to agitate the surface. All surfaces were cleared with DI water.
Conversion Coating	Sanchem's SafeGard CC 13062Mg RTU Coating was brush applied and left to air dry
Organic Coating	Hot application of clear microcrystalline wax



Before and after treatment, detail of camera

OBSERVATIONS

Based on the photomicrographs, the combined treatment, utilizing an initial mechanical cleaning followed by an acid immersion and a final conversion coating treatment was highly effective at mitigating corrosion while preserving the original surface treatments.
Why?
The Sanchem 560RTU cleaning acid clears active corrosion from pitted areas of magnesium where mechanical means cannot reach. This reduces the chance that corrosion will become active again, which is of great concern with magnesium.
The application of the SafeGard CC 13062Mg RTU provides a renewed layer of conversion coating over the exposed magnesium, protecting it from further corrosion.
The Sanchem cleaning acid had minimal effect on the original conversion coating; as much of the gold-colored appearance remained intact after the treatment.
The application of the SafeGard CC 13062Mg RTU was nearly transparent and did not visually alter the original surface. Areas of pitting and loss of the original conversion coating were still evident, thus presenting an honest representation of the object's condition while preserving the surfaces as they were originally intended.


Camera after treatment

CONCLUSION

Overall, this project improved the approach to treating magnesium corrosion at the National Air and Space Museum. The procedures outlined here have been successfully used to treat additional magnesium aerospace artifacts. The progress made on this project is part of ongoing research into magnesium alloy treatments at the NASM conservation lab.



Before and after treatment, detail of camera

ACKNOWLEDGMENTS

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