Investigations into the Characterization and Source of Corrosion on Anodized Aluminum Alloy Wrist Disconnects of Spacesuit Gloves at the National Air and Space Museum

Lisa Young[1], Christina L. Simms[1+2] and Aaron Shugar[2]
1. National Air and Space Museum, Smithsonian, 2. Art Conservation Department, Buffalo State

Background:

Spacesuit gloves are complex composite objects constructed of layers of outer synthetic materials with an interior pressure bladder adhered to an anodized aluminum wrist disconnect to attach it to the spacesuit (Figure 1). Many of these disconnects from the 1950s to 1980s housed in the National Air and Space Museum (NASM) collection exhibit signs of severe corrosion. Past research determined it to be chloride enhanced corrosion. For this study, a condition survey of approximately 300 spacesuit gloves and samples from Gemini and Apollo period gloves were investigated to characterize corrosion types present and to investigate the materials used in their construction. Analysis was performed with X-ray fluorescence (XRF) spectroscopy, scanning electron microscopy (SEM), X-ray diffraction (XRD) and Fourier transform infrared (FTIR) spectroscopy to develop a treatment protocol for the removal of chlorides, cleaning of the corrosion and stabilization of the metal without damaging the anodized layer.

Figure 1: Blue (left) and red (right) aluminum wrist disconnects are at base of gloves. Proto-type Apollo gloves by International Latex Company (ILC), 1966.

Manufacturing Process:

Metal hardware for the spacesuit gloves is produced by Air-lock Incorporated, now David Clark Incorporated. Soft materials (rubber, nylon, etc.) have been designed and assembled by several companies, but since the Apollo period spacesuits and gloves are assembled by the International Latex Corporation (ILC).

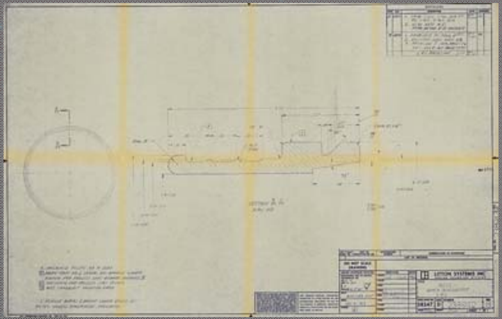


Figure 2: Blueprint demonstrating a cross-section of the wrist disconnect by Litton Systems, 1969. All samples in this study were made by Air-Lock Incorporated.

Disconnects are fabricated with the following steps (based on records and correspondence with manufacturers):

- Started with an extruded aluminum tube which was then machined.
- Aluminum alloys 7075 and 2024 were used, and research suggests 2024 was used for earlier models.
- Likely anodized using specification MIL-A-8625 Type II, Class II (Anodized using sulphuric acid with dye).
- Dye added to bath filled cavities in oxidized layer to create colored surface.
- Blue dye was used for the left glove and red dye was used for the right glove; colors range from gold to indigo in NASM collection.
- Sealed in deionized water, possibly with the addition of nickel or cobalt acetate.

Corrosion Types:

Gloss Loss (oxidation) and Pitting corrosion :

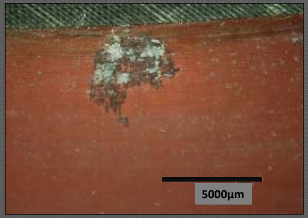


Figure 3 (left): Gloss loss/oxidation with pitting corrosion [white area]. Detail of figure 3 (right).

Exfoliation:

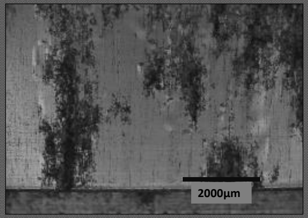


Figure 4 (left): Exfoliation corrosion found on light blue disconnect. Detail of figure 4 (right).

Yellowing

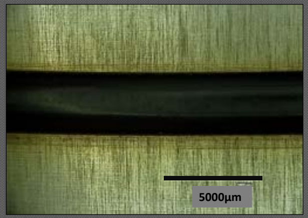


Figure 5 (left): Yellowing on metal caused by rubber on exterior of aluminum. The black line is a rubber o-ring. Detail of figure 5 (right).

Worn Anodized Layer

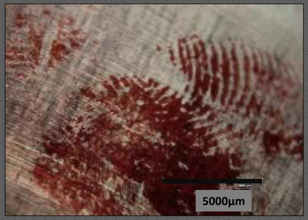


Figure 6 (left): Worn red dye on interior anodized layer. It is a fingerprint. Detail of figure 6 (right).

Results and Discussion:

The corrosion (see Figures 3 to 6) is more prevalent on the interior of the disconnects and at the interface where the soft materials are joined to the metal disconnect. Hydrochloric acid gas caused by deteriorating rubber components and human sweat are the likely sources of the chlorides. FTIR identified acetates on all samples indicating another form of corrosion, probably from the nickel acetate used in the anodizing process.

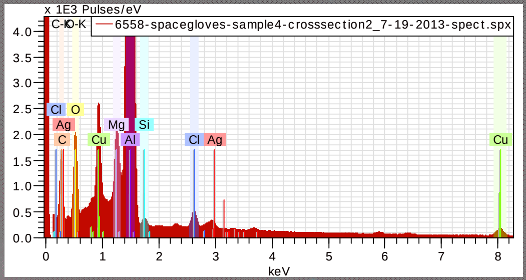
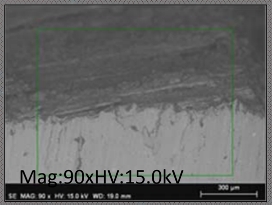


Figure 7: SEM spectrum of an Apollo period glove seen in Figs. 8-9

Samples were too amorphous for conclusive results with XRD. XRF and SEM results confirm the presence of chlorides (see Figures 7 to 9), expected metal constituents, and confirmed the use of two different alloys.

A higher copper content in 2024 Al may have caused these disconnects to be more susceptible to corrosion than 7075 Al. An anti-oxidant added to the rubber after 1971 (Apollo 14) also inhibited the breakdown of the rubber and therefore less off-gassing of the HCl occurred. The disconnects on these gloves were found to be more stable.



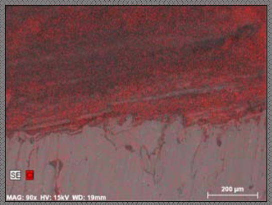


Figure 8 (left) is SEM image showing a cross-section of an Apollo period disconnect, the dark areas are corrosion. The red color Figure 9 (right) demonstrates the concentration of Cl, in the areas of corrosion.

Further Research:

Further research will include creating a passivating atmosphere using HCl scavenging materials, establishing how the chlorides participate in the corrosion process, and finding the best corrosion removal technique. The results of this research will inform future treatments of composite artifacts.

Acknowledgments: The authors would like to thank Cathleen Lewis, Jennifer Giaccai, Nicole Little, Willa Freedman, Jaleel Hill, Bill Ayrey, and Shane Jacobs.

Scan to download