

Corrosion Evaluation of Army and Automotive Materials in the Hawaiian Islands – 3-Year Update

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ABSTRACT

The US Army operates in many harsh and demanding environments throughout the world, which are highly corrosive. However, there lacks a basic understanding of the severity of these environments and their impact on the Army's materiel. To better understand this impact and broaden their database of information, the Army has established test sites on the Hawaii islands. These sites represent various climatic conditions the Army operates in. In these locations panel exposure of Army and automotive systems have been made to compare performance with that documented in the continental US by the SAE ACAP and past Army programs. Recently the first set of samples exposed have completed three (3) years of exposure. A secondary set has reached its first year of exposure and a third set have completed three (3) months of exposure. This paper will present a summary of the three year results and future work to be completed.

INTRODUCTION

The US Army operates in harsh and demanding environments throughout the world. During active duty its materiel can spend weeks shipboard during transport, operate in and around coastal environments, etc. As a result, their equipment can be exposed to corrosive conditions considerably harsher than anticipated for today's commercial vehicles.

Despite this operational requirement, little quantitative data exists for corrosion performance of the materials of manufacture for Army systems. While some components are similar to that of commercial systems, based on specific mission requirements the Army uses various grades of aluminum alloys, composites and a Chemical Agent Resistant Coating (CARC) system.

To further understand their requirements, the Army Corrosion Office (ACO) sponsored the Pacific Rim Corrosion Research Program (PRCRP). One of the

tasks under this program was to develop corrosion test sites throughout the Hawaiian Islands to quantify corrosion loss in similar climatic environments. This chain of islands is unique in that it contains a representation of most of the climates found throughout the world.

To further this understanding of these environments exposure of standard samples used by the SAE ACAP and samples representative of Army systems were exposed at two (2) test sites on the island of Oahu and two (2) sites on the island of Hawaii. In June 2007 samples on the island of Oahu completed three (3) years of exposure. Samples exposed on the island of Hawaii have completed completed one (1) year of exposure at Mona Loa and three (3) months of exposure at Volcanoes National Park.

EXPERIMENTAL APPROACH

This project is being done in support of the PRCRP, being executed by the University of Hawaii (U of H) for the ACO. Their tasking under the PRCRP includes the establishment and quantification of exposure sites within the Hawaiian Islands for corrosivity.

This project sought to leverage the establishment of the sites by the U of H to better understand how Army materials corrode in these environments, compare these results to standard SAE samples and utilize this and SAE historical information to better quantify the results obtained through accelerated corrosion testing. This was done by exposing samples with SAE standard automotive paint systems, Army Chemical Agent Resistant Coating (CARC) painted samples and mass loss coupons.

SAE SAMPLES

SAE samples were provided as-coated for exposure at the various sites established by U of H. Table 1 shows the list of samples provided by SAE. Prior to exposure

painted samples were scribed (two vertical scribes), mass loss samples were weighed to the nearest 0.1-mg and all samples were photographed.

Table 1. SAE Samples.

Sample Type	Sample Material	Number Exposed per Test Site	Frequency of Removal
Mass Loss	Aluminum (4-in x 4-in)	6	Yearly (duplicates)
	Steel (1-in x 2-inch)	6	Yearly (duplicates)
	Zinc (1-inch x 2-inch)	6	Yearly (duplicates)
Painted Samples	Aluminum (4-in x 6-in)	6	Yearly (duplicates)
	Galvanized (4-in x 6-in)	6	Yearly (duplicates)
	Steel (4-in x 6-inch)	6	Yearly (duplicates)

ARMY SAMPLES

Army samples were prepared for exposure by painting similar alloys with the water-reducible CARC system currently used by the Army. This includes a wash-primer (DOD-P-15328), epoxy primer (MIL-P-53030) and polyurethane topcoat (MIL-DTL-64159). All application was performed in accordance with the CARC application specification (MIL-C-53072).

Table 2 shows the samples prepared for testing.

Table 2. Army Samples.

Sample Type	Sample Material	Number Exposed per Test Site	Frequency of Removal
Painted Samples	Aluminum (4-in x 6-in)	6	Yearly (duplicates)
	Galvanized (4-in x 6-in)	6	Yearly (duplicates)
	Steel (4-in x 6-inch)	6	Yearly (duplicates)
	Aluminum Crevice (2-in x 4-in)	6	Yearly (duplicates)
	Steel Crevice (2-in x 4-in)	6	Yearly (duplicates)

MASS LOSS SAMPLES

Mass loss samples were also prepared for each site. These included aluminum (4-inch by 4-inch), carbon

steel (1-inch by 2-inch) and zinc (1-inch by 2-inch) to characterize the corrosivity of each exposure site.

SAMPLE EXPOSURES

In June 2004 samples were exposed at the Lyon Arboretum and Coconut Island U of H exposure sites. Three (3) such racks were installed at each test site allowing for easy removal at the completion of each exposure period. In May 2006 samples were exposed at the Mona Loa test site and in May 2007 at Volcanoes National Park.

Figure 1 shows a sketch of the modular racks. Figure 2 shows photos of the general areas where test racks are located. Figure 3 shows a representative exposure rack. Three such racks were exposed at Coconut Island, Lyon Arboretum and Mona Loa. Due to space limitations only one rack could be accommodated at Volcanoes National Park.

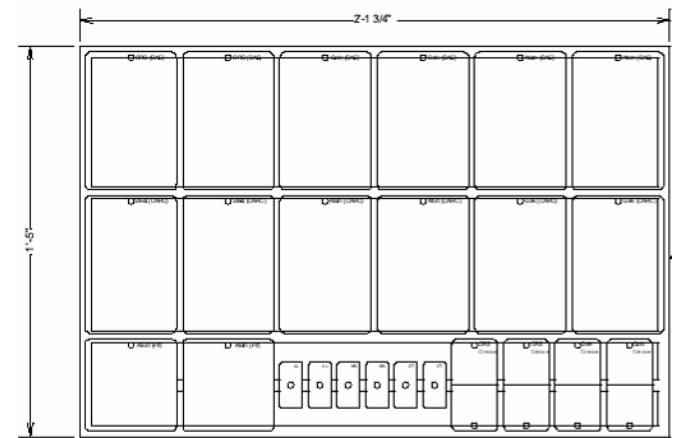


Figure 1. Modular Rack Sketch.

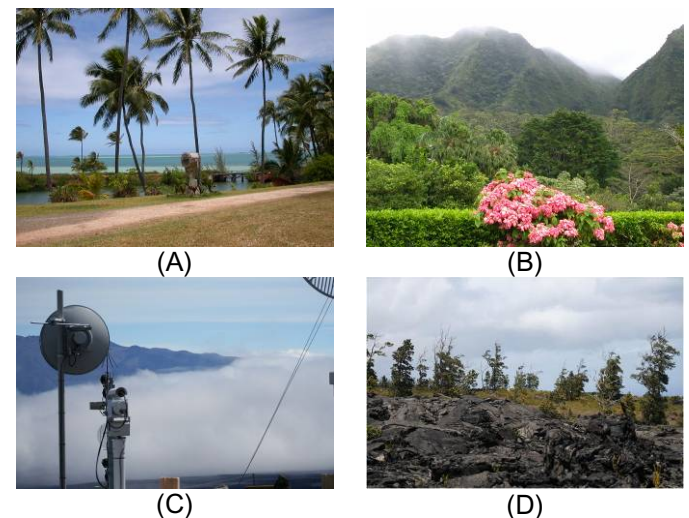


Figure 2. A – Coconut Island, B – Lyon Arboretum, C – Mona Loa and D – Volcanoes National Park.



Figure 3. Representative Exposure Rack.

The general climate of the sites are:

- Coconut Island – marine atmosphere.
- Lyon Arboretum – rainforest.
- Mona Loa – high altitude, alpine environment.
- Volcanoes National Park – high sulfur volcanic.

SAMPLE INSPECTIONS

During exposure samples were periodically visually inspected for deterioration during site visits by U of H personnel (nominally every 1-2 months). Using the following methods:

- ASTM D610 – corrosion through the paint system,
- ASTM D714 – blistering of the paint system and
- ASTM D1654 – cutback (creepage) from the scribes.

At the completion of exposures samples were destructively evaluated to determine cutback from the intentional scribes. evaluated by cleaning, although they were painted samples

Crevice samples were painted with the Army's CARC system and used to understand corrosion rates within tight geometries. The crevice samples are painted on all surfaces, except for a 25-mm diameter circle which is bare, allowing for free corrosion of the substrate within the crevice. Figure 4 shows a sketch of this type of panel.

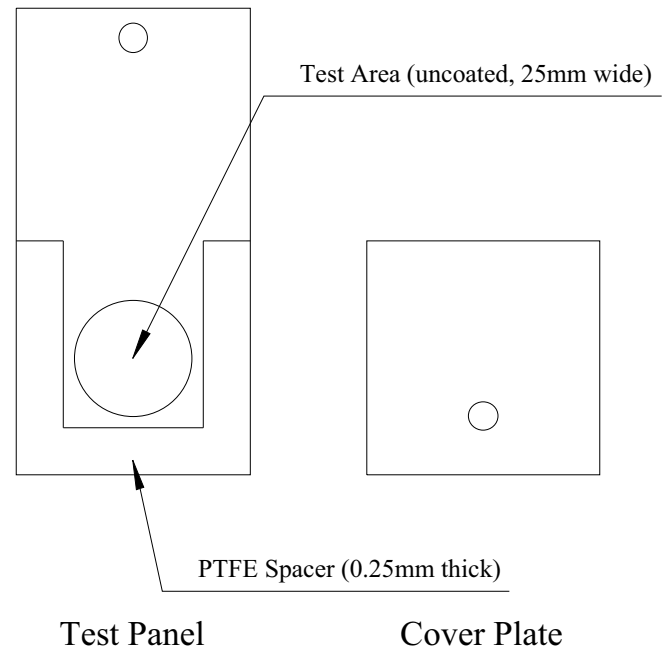


Figure 4. Crevice Panel Sketch.

After exposure is completed the uncoated area is cut from the sample and descaled removing corrosion products and coating materials. The sample is then weighed and compared with a theoretical weight based on the density of the material and volume.

The final set of samples was bare metal coupons exposed in the natural environments. These samples are used to quantify the general corrosivity of the environment represented as a corrosion rate.

Cleaning was performed on crevice and mass loss samples to determine overall corrosion rates.

- Aluminum – cleaned using 70% nitric acid solution,
- Steel samples – cleaned using 120-grit glass bead mixture,
- Zinc – cleaned using an ammonium persulfate and deionized water solution.

From these results

RESULTS

In June 2007 the final set of duplicate samples were retrieved from the Lyon Arboretum and Coconut Island sites. The visual and corrosivity results from three years of exposure are discussed herein.

PAINTED SAMPLES

Throughout the exposure period samples were visually evaluated for corrosion deterioration as shown by through-film corrosion, paint blistering or cutback adjacent to the intentional scribe.