

# The Marine Corps' War on Corrosion

Prioritizing maintenance to prevent deterioration

by Mr. Eric Brown & Mrs. Lauren Paladino

A little more than 25 years ago, the Marine Corps Corrosion Prevention and Control (CPAC) Program was established; its mission—to fight corrosion. Years of low-prioritization of necessary organizational-level corrosion maintenance had led to substantial deterioration of Marine Corps ground equipment, as the Marine Corps did not have the resources or process dedicated to corrosion prevention or repair. In fact, by 2004, corrosion was so prevalent 70.6 percent of assessed Marine Corps ground equipment required intermediate or depot-level maintenance to repair corrosion.

Corrosion can present itself in numerous ways, ranging from seized bolts, non-functioning electronics, and seized gun turrets. Mission success depends on equipment availability, and the effects of corrosion on performance are unacceptable. Unfortunately, even today, while corrosion health has improved, the enterprise still contends with system failures that require Engineering Change Proposals and equipment overhauls to mitigate the effects of corrosion. Force design has helped reduce the amount of equipment the CPAC program assesses and provided a means to divest of ground equipment requiring extensive corrosion repair. Nevertheless, corrosion of newly fielded equipment is making up for the lost quantities of divested equipment that required corrosion repair. This issue is exacerbated by way of the current requirements and acquisitions process of new capabilities.

Per DOD Instruction 5000, corrosion prevention and control begin early in the acquisition process. However, cor-

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rosion on newly fielded equipment is evidence that corrosion prevention and control is not a priority in program planning. In some cases, program managers are not including corrosion prevention requirements in the system specification or corrosion protection requirements in the contract to reduce program costs. This situation also applies to joint programs or Army programs the Marine Corps is leveraging. The Army and other Services operate in a different operational environment than the Marine Corps and corrosion prevention priorities are not the same. At the end of the day, the result of these decisions is the Marine Corps is fielding ground equipment without mitigating the effects of corrosion. Some of these corrosion issues will negatively affect equipment availability and readiness; most will reduce the intended equipment life cycle and require a costly overhaul. For example, the CPAC program has assessed assets that were within two years of the date of manufacture and identified the following issues:

- Inoperable emergency brakes.
- Seized engine access panels.
- Non-operational communications systems.
- Corroded wheel hubs.
- Cracked armor.
- Failed electrical connectors.

- Deteriorated fittings.
- Voids that see equipment rust from the inside out.
- Moisture retention areas where water pools, paint failures, and uncoated areas.

Figures 1 and 2 (on following page) are photos of corrosion issues on some of the Marine Corps' newest combat systems.

## The Fight

How is CPAC taking on this fight? CPAC is on the attack with a three-prong approach to address the issue. First, CPAC is engaged with equipment program managers to incorporate corrosion protection requirements early in the program development phase to address corrosion-prone design areas prior to production. CPAC can provide corrosion engineer support for Integrated Product Teams throughout the system lifecycle and most crucially in the design phase for specification development. This includes specifying the identification of high-risk areas, primer and paint, and corrosion preventive materials. At present, CPAC is actively engaged to help mitigate corrosion of more than fifteen programs. Teaming with equipment Program Managers is essential throughout the program's life cycle in order to address corrosion protection through program design



**Figure 1. Corroded hydraulic control unit fittings, suspension strut mount, and delaminated exterior paint coating exposing a bare metal substrate. (Figure provided by Eric Brown.)**

or to mitigate the effects of corrosion once fielded through modifications. The use of improper or incompatible materials during the design phase can lead to enduring corrosion damage. Reviewing designs for corrosion-prone areas, specifying build materials and processes, providing prime and paint requirements, specifying the application of Corrosion Preventive Compounds, and establishing corrosion quality control steps are all valuable inputs to the CPAC program can provide to equipment program managers to help mitigate corrosion. During the production process, CPAC assists with the review of Original Equipment Manufacturer (OEM) processes and provides recommendations on proposed system changes. Prior to fielding, CPAC assesses the system and creates a plan for preventive maintenance actions to reduce the effects of corrosion. If corrosion issues arise after the equipment is fielded, CPAC will perform a failure

analysis and develop a corrective action plan for the program manager's review and consideration.

The second approach is completed through organizational corrosion prevention. The contractor-supported CPAC Corrosion Service Teams (CST)

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are designed to complement Marine Corps condition-based maintenance efforts, with the goal to minimize the effects of corrosion and reduce the overall maintenance burden and cost on the FMF. The CSTs are at the tactical edge of the war on corrosion. In Fiscal

Year 2021, CSTs serviced and assessed over 60,722 pieces of equipment, resulting in a cost avoidance of over 91,000 maintenance hours that Marines could apply to their core MOS requirements. The CSTs extended the overall service life of ground equipment by applying corrosion prevention compounds, performed surface preparation and small area touch-up painting, and applied sealants. This was all done at the using unit's equipment lot, eliminating the need to evacuate the equipment for maintenance. During the assessment phase, the CSTs record the equipment corrosion conditions, which establishes the current state of equipment and drives future condition-based maintenance requirements.

The third approach is intermediate corrosion repair. The CPAC program operates Corrosion Repair Facilities (CRF) located at each MEF in four geographical locations. The CRFs perform corrosion repairs such as sheet metal



**Figure 2. Corroded electrical connections and paint failure leading to corrosion. (Figure provided by Eric Brown.)**



restoration, large surface area preparation, and prime and paint operations. In Fiscal Year 2021, 1,416 assets with extensive corrosion damage were repaired at CRFs. The advantage of completing repairs at the regional CRF is the equipment stays in the local area and is not shipped to the depot or OEM. Only when the corrosion is so severe (Category 5) and the CRF is not capable of repairing the equipment, it is sent to a depot, OEM, or in the worst-case scenario—disposal. Currently, there are over 250 corrosion Category 5 assets in the Marine Corps inventory.

### Technology Advancements

In addition to the three approaches and ensuring that CPAC is providing the FMF with the best product, the CPAC Engineering Team from Naval Surface Warfare Center Carderock continually researches industry advancements in corrosion-related processes, materials, and products. Over the past decade, the CPAC program has researched and implemented several materials and new processes, which have ultimately extended the useful life of Marine Corps equipment from three to seven-plus years in the absence of physical paint damage. One such process improvement has been the incorporation of a zinc-rich primer onto bare-metal surfaces prior to the application of topcoat Chemical Agent Resistant Coating (CARC) paint to prevent corrosion.

This coating acts as an additional barrier layer and provides sacrificial corrosion protection. For all assets, we have increased the thickness of the traditional CARC primer system and have proven that this additional 2 mil (.002”) of coating helps our assets withstand a maritime environment. For the high-wear areas that see a heavy foot and fork traffic, we have incorporated chip and abrasion-resistant coatings (bed liner) alleviating wear and ensuing corrosion of flooring and decking. The CPAC program has streamlined CARC best practices across all Marine Corps corrosion facilities to ensure consistent quality standards from one operation to the next. Another industry best practice the CPAC program has studied is a portable vacuum blast capability, which

will be an essential component of CPAC operations going forward. This capability will allow the CSTs to perform surface preparation without the need for a large-scale blast booth typically found at a CRF or depot. Leveraging this technology, the CPAC program will implement an enhanced CST corrosion repair capability where surface preparation and paint repair will be performed at the unit's location. This capability will enable an increase in the number of corrosion repairs by a CST, an increase in equipment available for the unit, reduced repair cycle times, and eliminated transportation costs to and from a CRF, depot, or OEM. While not a full replacement for the CRF, we argue this capability will be a force multiplier and may be an essential component for expeditionary corrosion repair.

### Are We Winning?

In 2004, 70.6 percent of Marine Corps ground equipment was in a condition that could lead to corrosion-related failures within five years; today, that number is 27.4 percent and getting smaller. While the program's proactive

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efforts have had a positive impact on corrosion, the Marine Corps cannot become complacent. More can be done to stave off corrosion, including unit-level training and the participation of Marine operators and maintainers when the CSTs are at their location. These same Marines can utilize the learned skills while operating abroad. As resources become more constrained, the CPAC Program has had to make some difficult program decisions over the past three years. In Fiscal Year 2020, one of two CSTs and a contracted mobile CRF, responsible for the service, assessment, and repair of Marine Forces Reserve equipment were divested resulting in the extension of equipment service intervals

and vehicles not being repaired. Future funding reductions across the Future Years Defense Program to CPAC could result in the divestment of a CRF for at least one MEF.

As the Corps focuses on the implementation of *Force Design 2030*, the CPAC program envisions additional and potentially more significant corrosion concerns on the horizon. The future operating environment will expose Marine Corps equipment to the highest corrosion conditions in the world. The persistent posturing in the seaward/landward portion of littoral environments will cause extreme corrosion, up to three times that of current rates, on systems that are integral to the *Force Design 2030* operating strategy such as the Joint Light Tactical Vehicle and the Amphibious Combat Vehicle. Moving forward, assessments, program management office engagements, and CST operations are the priority of effort for CPAC.

Failure to provide preventive and corrective corrosion services can cause loss of functionality of essential hardware and electronics systems, rapidly increase maintenance needs beyond field-level repairs, and contribute to the increased mean time between failures and the loss of equipment availability. Ground equipment sustainment and prevention of corrosion are critical to maintaining forward operations to satisfy expeditionary advanced base operations and littoral operations in a contested environment. With this in mind, the Corps' current corrosion mitigation methodologies may not be robust enough to meet the demand.

CPAC is committed to continuing to innovate and build on proven methodologies to support the Marine Corps with these challenges in the years ahead. CPAC is taking a proactive approach to study and understand the effects of harsh operating environments like those found in the Pacific. CPAC is identifying gaps, assessing future FMF needs, and will continue to refine strategies that will enable the Marine Corps to win the fight against corrosion.

