Nomination Narrative
Individual/Team: Environmental Excellence in Weapon System Acquisition (Small Program)
Tagnite Technical Working Team

Narrative

Introduction

The Army requires environmentally sustainable maintenance practices and, in furtherance of this objective, is actively engaged in reducing or eliminating the use of hexavalent chromium from our depot practices. Hexavalent chromium is a known human carcinogen and is continuing to receive increased domestic and international regulatory scrutiny. Any reduction in the permissible exposure limit could make processes that use or generate hexavalent chromium unsustainable or impractical. Obsolescence of these processes by suppliers due to regulatory restrictions is a credible risk. In fact, a risk assessment by the Department of Defense (DoD) Chemical and Material Risk Management Directorate confirmed that there is a significant risk to sustainability if we do not develop and implement more sustainable non-hexavalent chrome processes for component parts. In response to this, the DoD has targeted hexavalent chromium for elimination and/or reduction on all weapon systems. To effect this change, new Defense Federal Acquisition Regulation Supplement (DFARS) regulations have been issued for new procurements and a directive by John Young, Office of the Under Secretary of Defense for Acquisition, Technology and Logistics (USD(ALT)) instructs all military departments to be actively engaged in an effort to reduce its use across all weapon systems. Lastly, recently promulgated European Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH) regulations could place significant pressure on supply chains for hexavalent chromium and may also impact the CCAD's foreign military sales (FMS) customers.

One significant source of hexavalent chromium in the depot environment is in the surface treatment of magnesium components. To address this requirement, a joint effort between the Aviation and Missile Command (AMCOM) G-4 Environmental Division; Army Research Laboratory (ARL); Aviation and Missile Research, Development and Engineering Center (AMRDEC) AEF; AMRDEC AEM; Air Force Research Laboratory (AFRL); Corpus Christi Army Depot (CCAD) Materials Process and Engineering Division (MPED), Program Executive Office (PEO) Aviation and Technology Applications Group successfully developed and demonstrated a manufacturing capability that allows the application of Tagnite anodizing (immersion and brush applied) to legacy magnesium components at CCAD. Compared to legacy surface finishes such as HAE, DOW 17, DOW 9, or DOW 7, Tagnite anodizing is considered to be a more environmentally sustainable process for protecting magnesium and when combined with applicable organic coatings, provides a more durable and corrosion resistant surface finish than traditional surface finishes. Any reduction in magnesium component attrition from corrosion damage offers a significant economic payback for implementation of this technology.

From the perspective of environmental sustainability, the Tagnite process does not use hexavalent chromium, alleviating future regulatory challenges that have the potential to affect aircraft readiness by restricting current maintenance practices based on this chemistry, including all depot-applied magnesium surface finishes. The immersion and hand-applied Brush Tagnite anodize processes replace both current magnesium dip processes (DOW 7 and DOW 9), as well as reduce or eliminate the use of chromic acid touch-up (DOW 19).

Background

Tagnite anodizing is the most thoroughly researched (alternative) process by DoD for protection of magnesium. In the early stages of research, the Environmental Technology Acquisition Program (ETAP) funded an investigation of this technology through its Sustainable Painting Operations for Total Army (SPOTA) Program. Later, the Industrial Base Innovation Fund (IBIF) innovated the custom masking materials and provided a proof-of-concept showing that legacy parts could be anodized with Tagnite. To show that this process could be performed in a depot environment, a demonstration was supported by the Environmental Security Technology Certification Program (ESTCP), with supplemental support provided directly to CCAD from ETAP's Toxic Metal Reduction (TMR) Program. The concerted effort from these various environmental organizations and a diverse team comprising of ARL, AMCOM G-4 Environmental, AMRDEC AEM, AMRDEC AEF, CCAD MPED, PEO Aviation, AFRL and Technology Applications Group ensured this project to be a success.

Besides being more environmentally sustainable than traditional surface finishes, Tagnite provides better corrosion and abrasion resistance, especially when over coated with a hard resin, primer and topcoats. The culmination of over 25 years of research by various DoD entities has resulted in a number of authorizations for use by the AED, the Naval Air Systems Command (NAVAIR) and several commercial entities including Boeing for use on the AH-64 Apache and by Sikorsky for the UH-60 Blackhawk. The process is not without certain drawbacks, however. It does require the use of high-voltages, the use of some fluorides in the activator step, a specific formulation is required to treat QE-22 magnesium alloy which also uses a small amount of vanadium pentoxide, and lastly the process requires tank chillers. However, the overall effect provides benefits in the form of longer-lasting components and environmental sustainability.

Traditionally, the application of Tagnite anodize has only been available to original equipment manufacturers (OEMs), who have the opportunity to apply the most robust protection systems before it is combined with steel inserts and liners into assemblies. CCAD, on the other hand, has to cope with mixed-metal assemblies that cannot be disassembled, as well as used, corroded, fatigued and possibly battle-damaged components. Less robust protection systems such as DOW 7, DOW 9, and DOW 19 are employed mainly due to the mixed-metal applications. In addition, Tagnite anodizing will react violently with ferrous metals resulting in rapid oxidation of the steel substrate as well as damage to the surrounding magnesium.

However, the IBIF effort previously developed and demonstrated the use of novel aluminum masking agents to protect the dissimilar metals in the assembly during the application of Tagnite. The process primarily used custom designed, strategically placed aluminum masking materials with silicon o-rings and UV-curable maskants (**Figure 1**). The process increases the required man-hours per part but potentially imparts a far more robust surface finish than what is currently employed. The implementation of this process will drastically improve part-life and thereby lower life-cycle costs.

Figure 1: *Example AH-64 Tail Rotor Gear Box in the blasted condition (1), after the application of custom-designed masking agents (2), and after the application of Tagnite (3).*

As part of the current ESTCP effort, the study team was able to demonstrate the viability of the masking process in a depot environment (**Figure 2**). The main working group was composed of members from various DoD and industry organizations including Technology Applications Group, AMCOM G-4 Environmental, AMRDEC AEM, AMRDEC AEF, CCAD MPED, PEO Aviation, AFRL, and ARL as the lead. The effort was endorsed by the CCAD Commander and resulted in the installation of a pilot-scale Tagnite process line at CCAD where beyond economical repair (BER) parts were processed as part of the demonstration. The next step will be to scale up the pilot line to a full-production capability. In addition, other notable accomplishments of the project are as follows:

- Developed a process for treating legacy magnesium components that is free of hexavalent chromium, which not only reduces workers' exposure to the known human carcinogen, but alleviates future regulatory challenges that have the potential to affect aircraft readiness by restricting current maintenance practices based on this chemistry, including all current depot-applied magnesium surface finishes.

- Demonstrated the compatibility of Tagnite anodizing with current and potential magnesium repair techniques including aluminum Cold Spray, TIG welding, DEVCON aluminum liquid, electron beam welding, titanium paste, HVOF, etc.
- Designed and validated a sodium bicarbonate stripping process that allows legacy surface finishes to be removed prior to Tagnite re-anodize and alleviates concern with blockage of fluid passageways.
- Generated performance data for Brush Tagnite with other magnesium aerospace alloys AZ91C, AZ91E, QE22, WE43, and EV31.
- Developed and demonstrated the use of novel aluminum masking agents to protect the dissimilar metals in the assembly during the application of Tagnite and applied them to two dozen of the highest-priority parts.
- Trained plate shop personnel at CCAD to apply both the immersion and brush Tagnite techniques to get the most durable and effective coating possible.

Figure 2: *As part of the ESTCP Demonstration, a UH-60 Output Housing is masked (1), Tagnite anodized (2), sealed with Rockhard*.

Future efforts supported by ESTCP will allow the study team to develop Brush Tagnite (BT-12) techniques to decrease operator time and increase throughput. ETAP's Securing the Availability of Green, Enhanced Coatings (SAGE-Coat) Program will explore hazardous air pollutant (HAP)-free, low volatile organic compound (VOC) alternatives to the current sealer applied to magnesium anodized parts, Rockhard. These efforts will further enhance the results of the already superior Tagnite process.

Discussion

1. Tagnite anodizing at CCAD will allow legacy magnesium castings to be retrofitted with Tagnite. Significant savings are expected due to fewer corrosion-related removals of magnesium castings.
2. This effort will improve the sustainability and robustness of depot-applied magnesium protection system, while also allowing CCAD to phase-out the use hexavalent chromium in magnesium finishing. Any improvement in the rate of component removals due to corrosion should provide significant economic payback for the implementation of this technology. This process is the first step in completely eliminating the use of hexavalent chromium in magnesium finishing at CCAD. If all major weapon system platforms authorize the use of Tagnite on legacy weapon components, CCAD will eliminate exposure risk to depot personnel and significantly increase the sustainability of this maintenance practice.
3. Once all major weapon system platform Program Managers (PMs) and OEMs transition to Tagnite coatings, the resulting streamlining of maintenance processes throughout the

lifecycle of the weapon systems will produce additional savings. In addition, CCAD will not have to remove the hexavalent chromium from the components once they arrive at CCAD.

4. The Tagnite anodizing is fully compatible with new Cold Spray repair techniques. This compatibility allows damaged magnesium components to be repaired and subsequently treated with Tagnite, allowing for recovery and reuse of housings that were previously BER.
5. This technology opens the possibility of leaving Tagnite on faying surfaces during the fabrication of new components by OEMs. The concept is for the casted and machined housings to receive all steel inserts and liners, and be final machined to tolerance, prior to the application of Tagnite. The masking agents would then be employed to protect the component during Tagnite application.
6. Lastly, by providing this capability to CCAD, it opens the possibility to eventual use by future weapon systems such as Future Vertical Lift (FVL).

Conclusions

Based on the previous discussion, the re-anodizing of magnesium components using Tagnite will significantly increase the environmental sustainability of maintenance practices for magnesium at CCAD. An added benefit of this process is that the use of Tagnite anodizing imparts a more robust protection system to the component parts than what is traditionally applied. The improved corrosion characteristics will result in fewer corrosion- related removals from service and provide economic justification for implementation of this technology. In addition, the acceptability of this process by all weapon system PMs, OEMs, and other Services would also provide benefits due to streamlining of maintenance practices, and reduction of hexavalent chromium at the start of the component life-cycle.

Judging Criteria

1. **Program Management**: Did the nominee manage and document the ESOH effort to meet acquisition program/capability requirements and to reduce ESOH related drivers of total ownership costs over the system life cycle?

The project team ensured early in the process that all requirements would be met by entering into a Technology Transition Agreement with all relevant parties, including CCAD and PEO Aviation. The team worked with cognizant engineering authorities and PMs to ensure approval and eventual transition of this new process as part of life-cycle management. The new technology will reduce life cycle costs by avoiding cleanup and compliance costs associated with the previous hexavalent chromium-containing process. It will also minimize maintenance costs by providing a robust coating on magnesium parts to extend their service lives and servicing parts that would otherwise be BER.

2. **Technical Merit**: Did the technical merits of the nominee's ESOH effort integrate life cycle ESOH risk management into the systems engineering process using the methodology in DoDI 5000.02, Operation of the Defense Acquisition System,

Incorporating Change 3, August 10, 2017; MIL-STD-882D, DoD Standard Practice for System Safety, February 10, 2000; and MIL-STD-882E, Department of Defense Standard Practice: System Safety, May 11, 2012? Are the nominees' accomplishments distinct from past successes, and if so, how are they significant?

Yes, risk management was taken into account in accordance with the appropriate regulations and standards and by executing the program, the technology advances the goal of integrating life-cycle ESOH risk management into the systems engineering process. The effort also addresses a larger DoD effort to eliminate the use of hexavalent chromium as outlined in an OSD risk assessment. The accomplishments of this project are distinct from past accomplishments in that historically, hexavalent chromium is used in the anodizing of magnesium parts. While hexavalent chromium provides good corrosion protection, the process is not sustainable, as hexavalent chromium is a known human carcinogen and is being tightly regulated by various organizations both domestically and abroad to lower the exposure limit or ban certain uses of the chemical altogether. With an international move away from hexavalent chromium, the process would become obsolete as well as posing a health risk to maintainers. This process avoids those risks while providing a robust coating system to minimize maintenance and extend the service lives of magnesium parts.

3. **Orientation to Mission**:
    a. Did the program orient its ESOH effort to optimize mission sustainability, mission readiness, and total ownership costs?

This program is essential to mission sustainability. By incorporating a hexavalent-chromium free technology to the repair of magnesium parts, the process can avoid obsolescence associated with the previous process as national and international regulations are becoming more stringent. At the same time, the process ensures mission readiness by repairing parts that would otherwise be BER, bringing parts back into service faster and with a more robust coating system. Finally, total ownership costs are reduced by extending the service lives of magnesium parts, as well as servicing parts that would not otherwise be serviceable, saving on the cost of new parts.

    b. If it was a program requirement, how effectively did the ESOH effort help meet urgent military needs (e.g., rapid fielding) through agile and flexible application of ESOH expertise to support developing, testing, and fielding of new military capabilities?

N/a

4. **Transferability**:
    a. How well did the program incorporate ESOH lessons learned from similar legacy systems and mishap data from the Service Safety Centers?

N/a

    b. How well did the nominee communicate ESOH risks effectively to others?
    c. Did the nominee ensure that they transferred mitigations through lessons learned to other weapon system programs?

Yes, the project team is initially demonstrating and implementing the process on UH-60 components, with plans to transfer lessons learned to other PMs to ease their transition.

5. **Stakeholder Interaction**: How effectively did the nominee execute and document the ESOH effort in the SEP, the PESHE, and the NEPA/E.O. 12114 Compliance Schedule?

N/a, applies to systems in sustainment.

6. **Impact/Outcomes**:
    a. Will the technique and/or program endure over time?

Yes. In fact, this process should only gain more support as national and international regulations on hexavalent chromium become more stringent and alternatives become more imperative.

    b. Is there a framework in place to build on/improve the nominee's accomplishments in the future?

Yes. There are plans to scale up the pilot line at CCAD to accommodate larger parts. This entails providing additional power to the installation to accommodate the higher voltage requirement. There are also plans to improve the technology. Notably, the study team will develop Brush Tagnite (BT-12) techniques to decrease operator time and increase throughput. They will also explore hazardous air pollutant (HAP)-free, low volatile organic compound (VOC) alternatives to the current sealer, Rockhard, applied to magnesium anodized parts.

Aside from improvements in the technology and scaling up at CCAD, the technology has the possibility to be applied to other installations and Services, including NAVAIR and the Air Force.