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Corrosion Control Tool Kits for Effective Corrosion Removal and Surface Preparation

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ABSTRACT

The goal of the project is to enhance surface preparation in order to improve coating adhesion to the substrate. The present practice of removing rust from Chemical Agent Resistant Coating (CARC) coated surfaces is to use a paint scraper, wire brush and grinder. The individual performing the removal must wear a Tyvek™ suit, full-face respirator, and other personal protection equipment and the individual also has to attend respirator training. The focus of this project is to demonstrate that Army Corrosion Kits eliminate the need for the Tyvek™ suits, full-face respirators, and other personal protection equipment while providing a better prepared surface. The kits provide a way to collect the dust as it is being generated. The objective of

the first echelon rust removal is to control or remove the corrosion and thereby eliminate the need for costly depot (second echelon) restoration. User friendly dust-less tools and HEPA (High Efficiency Particulate Air) filtered portable vacuums are used to help accomplish this, as well as minimize clean-up time and waste.

Keywords: Army, Corrosion, Surface Preparation, Tool Kit, Corrosion Removal.

INTRODUCTION

U.S. Army Corrosion Office (ACO) at ARDEC is investigating new and innovative ways to remove corrosion and paint for effective repair of equipment from the field while reducing operator exposure to hazardous materials generated during these operations. The program was initiated by Office of Corrosion Policy and Oversight out of the Department of Defense who initially funded the program, follow on efforts were funded through the Department of the Army. The Army Corrosion Office identified DCM Clean Air Products Inc, a contractor who builds special tool kits for the specific purpose of removing corrosion, as a potential supplier of equipment that would fulfill the DOD requirements. Under the scope of the program, tool kits were purchased from DCM and supplied to different service locations across the United States to include: Fort Polk, Fort Stewart, Fort Bragg, Camp Santiago, Fort Hood, Fort Bliss and Fort Sam Houston. The contractor, in addition to supplying these kits, provided onsite operator training. A major component of the program is collection of cost data to refine the return on investment (ROI) calculation for paint and rust removal.

Background

The present practice of removing rust from Chemical Agent Resistant Coating (CARC) coated surfaces is to use a paint scraper, wire brush and grinder. The individual performing the removal must wear a Tyvek™ suit, full-face respirator, and other personal protection equipment. Individuals performing this operation must attend respirator training. An industrial hygienist is required to constantly take air samples and monitor the individual's exposure to the dust, which is considered hazardous. The health issues of having the rust removal working area and surrounding air contaminated with CARC paint, cadmium and chromium dust and flakes are impacts that this project would ameliorate. Also, if the corrosion has not been completely removed, the affected area will eventually corrode again and this corrosion may progress to stages beyond repair or require they be prematurely sent to a depot for complete restoration. Events such as this cost the Department of Defense (DOD) billions of dollars annually. The poorly

executed repairs may critically reduce the reliability of the vehicle or equipment and may lead to an inability to support the mission. The poorly executed repairs also may result in an unsafe vehicle or equipment, which might then result in needless injury or death if a resultant failure occurs when trust is unwittingly placed in the faulty equipment or vehicle.

PROGRAM APPROACH

The program was set up so that DCM Clean Air equipped specific locations, as designated by the Army, with the tool kits (Figure 1). On site personnel were then trained on how to properly use the kits for optimum effectiveness. The personnel trained were the ones who will train all other personnel that come through the base. This allows for consistent and continuous training of the tool kit operators.

Figure 1. Tool Kit

The current method of paint and rust removal used at many Army and Marine Corp facilities generates hazardous dust to which the operator is exposed. Furthermore, the surface prepared by the current method is inadequate which may result in rapid rusting. The objective of performing this operation with corrosion tool kits is to minimize these problems. Testing is ongoing to determine if the kits are more effective in removal of rust and preparation of the surface for painting. The data collected will be based on Mean Time to Repair (MTTR) and Mean Time Between Failure (MTBF) of the equipment that is being repaired with the tool kits and then returned to the field.

Under the DOD funding, Fort Polk, Fort Stewart, Fort Bragg and Camp Santiago each received three tool kits. In addition to the kits, training was provided by DCM Clean Air products to each of the facilities. The kits are now at the maintenance facilities for use as necessary. The kits are currently not used on a daily basis due to the deployment of personnel. Therefore more locations under the Army's funding were sent tool kits in order to gather the necessary data. While they have been used at some bases, current usage does not necessitate changing Standard Operating Procedures (SOPs) due to deployment of the personnel. Instead the technical bulletin TB

43-0213 Corrosion Prevention and Control Procedures for Tactical Wheeled Vehicles and Trailers is being updated by TARDEC to incorporate the tool kits procedure.

The tool kits are set up to be used in the maintenance facilities to remove the paint and rust from problem areas and to prepare the surface for application of new coatings. Once the problem areas on the equipment have been prepared, a new coating is applied and the equipment is returned to the field. This is the first echelon of rust removal. The objective of the first echelon rust removal is to control or remove the corrosion and thereby eliminate the need for costly depot (second echelon) restoration. User friendly dust-less tools and HEPA (High Efficiency Particulate Air) filtered portable vacuums are used to help accomplish this as well as minimize clean-up time and waste. The dust-less, shrouded tools contained in each kit consist of a: needle-scaler, two inch right angle grinder, eight inch diameter Random Orbital Sander, five inch diameter Random Orbital Sander, a detailed sander, a portable five gallon HEPA vacuum that suctions the dust during tool use, a tool kit case and an assortment of consumable items used with tools. Several of the tools are illustrated in Figure 2. The Marine Corps has already purchased 284 of these kits for their bases, with a commitment for 44 more. Training was included as part of the purchase price for kits sold in the US.

3.5 inch Ergo-lite®

Needle Scaler Kit

5 Gallon Vacuum System

Posi-Vac Starter Kit With Grinder

Figure 2. Sample tools

The scope of this program was to distribute kits and training to other locations throughout the United States. This was due to the deployment of the personnel at the initial locations. In order to acquire the appropriate data, more kits needed to be used. In addition, through laboratory and outdoor exposure testing, the ACO will assess the benefits of the kits in terms of improvements in surface preparation and its effects on survivability. In FY06, kits procured with Army funding were distributed to Fort Hood, Fort Sam Houston and Fort Bliss, all of which are in Texas. All the kits at each location have a two year

maintenance program with them so the contractor will return each month for twenty-four months to check up on each kit. The maintenance program includes changing the HEPA filter, any of the sand paper for the tools, making sure the equipment is working properly and fixing any parts that need repairing.

Experimental Procedure

The ACO plans to conduct testing with the kits to demonstrate the efficacy and establish and ROI for use. The specific objectives of the study are to demonstrate:

1. Tools more efficient therefore decreasing the MTTR
2. Gives a better surface for repainting, which will be done in ACO's laboratory
3. Repair lasts longer because the surface is better prepared thereby extending the MTBF
4. ROI based on longer life in addition to less labor.

The data collected will include length of time it takes to use the kit as compared to any other method currently being used in the maintenance facilities (the MTTR) and the mean time between failures (MTBF) of equipment returned to the field that has been repaired with the kit and current methods. The clean-up time and waste produced will also be monitored in order to complete the data collection.

DCM has already completed an air quality test while using the tool kits. The air quality testing was completed by EcoSystems Environmental, Inc, the test was conducted at the Naval Air Station – Joint Reserve Base in Fort Worth, Texas. The samples collected contained Lead/Cadmium, Respirable Silica, Hexavalent Chromium, and bulk CARC paint, containing all of the above in one sample. The sampling was done as the tool kits were being used by the trained personnel. Collection of these samples was done as per Occupational Safety and Health Administration (OSHA) and the National Institute for occupational Safety and Health (NIOSH) regulations. Results of the test can be found in Table 1.

Component	Concentration (mg/m^3)
Cadmium	0.000078
Lead	Below Reporting Limit
Quartz (respirable silica)	0.039
Hexavalent Chromium	Below Reporting Limit
Bulk CARC Paint	
Cadmium	0.0045
Lead	5.3

Cristobalite	4.4
Quartz	5.7
Hexavalent Chromium	0.56

Table 1. Health Report Results

The report is included in the training video that has been given to all the sites where training has occurred. The results for MTTR shall be assessed and analyzed soon, but the data to determine the MTBF will take longer to analyze.

The ACO will also conduct their own investigation to assess the effectiveness and efficiency of the current methods of corrosion removal as compared to the kits. There will be four phases to this testing. Phase one (Phase I) of the testing will be as follows:

1. A set of samples made from 1018 alloy steel will be flash rusted.
2. Several panels will be cleaned by each of the following methods: the corrosion control tool kit, a demo grinder, and a wire brush (field repair). The current method is using a demo grinder or sandpaper and a wire brush, depending on where the user is located. Repair in the field does not include a demo grinder.
3. The surfaces of each will then be analyzed to see how well the corrosion was removed. Optical microscopy and visual inspection will be used to inspect for corrosion. A cross section of the surfaces will be analyzed with a scanning electron microscope (SEM) to see any surface morphology.
4. The samples will then receive a pretreatment and be painted with a water based primer, MIL-P-53030 and top coat, MIL-DLT-64159II.
5. Some of the samples will be tested using hydraulic adhesion testing equipment (HATE), this will be a procedure as prescribed by Army Research Labs (ARL), ASTM 4541. Since it is a destructive test only one from each method will be tested using HATE.
6. Electrochemical impedance spectroscopy (EIS) testing will be performed on the samples.
7. A set of each panel type will be placed in an accelerated corrosion chamber for 24 cycles and tested using SAE J2334, ASTM D174, and ASTM D1654 in accordance to the Army's Joint Test Protocols (JTP).
8. After exposure, HATE testing will be performed on the exposed samples.

The second phase (Phase II) of the testing will use steel panels that have been previously exposed, as opposed to new panels. The panels will have been exposed to marine environment conditions at LaQue Beach for 46 months. These panels have no coatings on them initially. They will be cleaned and analyzed in the same manor as delineated above.

The third phase (Phase III) of testing will use 1018 steel panels that have been flash rusted, and then testing differs from Phase I in that instead of using

the accelerated chamber they will be placed outside on the ACO's Corrosion Instrument Test Yard (CITY) for two years in a seasonable environment to gather real time exposure date. After two years the testing will continue as stated in Phase I.

The fourth phase (Phase IV) of testing will use previously exposed panels as in Phase III. They will have been in a marine environment at LaQue Beach for 46 months. The testing will be similar to Phase III in that instead of putting them in an accelerated chamber they will be placed outside on the ACO's corrosion instrument test yard (CITY) for two years in seasonable environment to gather real time exposure data.

Return on Investment (ROI)

The return on investment was calculated based on the initial funding provided by DOD and the additional Army funding. In fiscal year 2005 the program was funded through DOD. The corrosion tool kit information was estimated based on the cost of the kits ($8,603.00) and the support costs ($860.00) were estimated based on labor and extra materials, see Table 2. The cost current methods ($57,250 per year) were found from Army documentations, see Table 3. Based on the data, a useful life savings over a twenty year time span is estimated to be approximately $41.6M. This is based on 250 tool kits divided by three years multiplied by the ten year savings (Table 3) by two. This estimate is considered to be conservative because the benefits realized through better surface preparation and the resulting extension in service life were neglected in the equation. The total Army and DOD costs for this program were approximately $2.4 M. When the project cost is divided into the useful life savings yields, an ROI of 17.58 is calculated, see Figure 3.

Corrosion Tool Kits	FY06	FY08	Total Costs
Cost of One Unit	$8,603.00	$8,603.00	
Support Cost @ 10%	$860.00	$860.00	
Total Cost per Unit	$9,463.00	$9,463.00	
Number of Units	150	100	250
Total Funding Needed	$1,419,495.00	$946,330.00	$2,365,825.00

Table 2. ROI for Corrosion Tool Kits

Based on 3 Kits		Current		Tool Kit
10 Year		10 Years		10 Years
Equip	$570	$5,700	$25,809	$25,809
Materials	$2,080	$20,800	$2,680	$24,120
Labor	$54,600	$546,000	$27,300	$273,000
		$572,500		$322,929
			Ten Year Savings	$249,571

Table 3. Current Method Prices vs. Tool Kit Prices

- ULS (Useful Life Savings)= $41,595,166.00
- PC (Project Cost)= $ 2,365,825.00
- ROI= ULS/PC= 17.58

Figure 3. ROI formula.

RESULTS

While data collected to date demonstrates a significant ROI in terms of labor associated with paint and rust removal along with a significant reduction in operator exposure to hazards associated with performing this operation, data to demonstrate the efficacy of the repair has not been collected. Currently several Army bases have been using the kits and data is still being collected to determine the MTTR and the MTBF. Deployment of equipment has delayed the collection of these data.

This data will be supported by laboratory tests to be conducted in the ACO. It is anticipated that collection of data to support an extension of service life through the use of the tool kits on actual assets will be costly and time consuming. Therefore through the use of surface analysis and accelerated corrosion testing in accordance with Joint Test Protocols the MTBF will be determined.

CONCLUSIONS

The program has identified and facilitated a new method of removing corrosion and surface preparation. To date the tool kits have not been used for any purpose other than military application. Data is still being collected to

demonstrate that the tool kits are more effective and efficient than the methods currently employed. The confidence level that the tool kits are more effective is high. Once all the data has been collected and analyzed, a conclusion on the real benefits, to include cost savings, of the program can be drawn. Based on a small set of preliminary data that is still being verified, these kits do appear to reduce the time required for making these repairs. With ongoing support from the Army, the effort will continue generating data to determine the best approach for corrosion removal from equipment. Since the final outcome of this study will be based on long-term data collection, it is premature to state the overall efficacy of these kits and the resultant lessons learned at this time.

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