Improving Military Readiness through Innovative Coating Application Technologies & Training

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INTRODUCTION

The effectiveness of US military forces is largely dependent on the readiness of the equipment and vehicles they use. One process in particular that plays an important role in the overall readiness of military equipment is the spray application of coatings. This is significant because it is such a pervasive process within the Armed Forces. Spray-applied coatings are used for many types of equipment, components and vehicles including aircraft, ground vehicles, water-borne vessels and ordnance. For example, if a coating has to be re-applied because it was poorly applied in the first-place, re-deployment of the vehicle will be delayed, thereby straining military readiness. Coating re-application also results in increased usage of labor and materials, thus increasing overall maintenance costs. Improved coating application quality therefore results in reduced cost and increased readiness.

Spray Application by the DoD

The DoD has implemented some of the most advanced coating systems ever created. However, the performance of these coatings is dependent upon the effectiveness of their application. Since coatings are designed to perform specific tasks, they are typically very expensive. By using high performance coatings efficiently, the DoD can realize significant monetary savings through the reduction in coating purchases, material rework and waste disposal. Training has been the conventional route to improving the quality of coating application, but advances in both spray application technologies and training programs have brought the quality of coating application to the next level. This article describes some of the nuances of the coating application process that affect the quality of the coating and also presents a special training program and new technologies that have been developed to help coating applicators improve the quality of their coatings.

THE COATING APPLICATION PROCESS

Applying coatings using a spray gun (Figure 1) is a skill that can only be mastered through effective hands-on training and years of experience. However, the fundamental skills and knowledge required for acceptable DoD coating application can be passed on through effective education and training. Coating application effectiveness can generally be evaluated based upon three factors of application outcomes: efficiency, accuracy and consistency. In addition to these three factors, spray applicators must also possess the knowledge required to effectively prepare surfaces and coating materials and safely dispose of the waste products which could contain hazardous materials.

Spray Gun Settings

In order to efficiently apply coatings, spray applicators must understand and follow several techniques. One of the most important preparatory steps is properly setting up a spray gun so that it operates at its maximum efficiency. A common mistake in setting up the gun is using excessive air pressure, which reduces the amount of paint that adheres to the part. Properly adjusting the fan pattern, air pressure and fluid flow can drastically affect the efficiency with which coatings are applied to substrates.

Coating Application Parameters

Other techniques that can improve efficiency include the reduction of lead and lag space* and maintaining the proper spray gun-to-substrate distance. Also of primary importance is maintaining an appropriate speed with which the spray gun is moved while taking into consideration the particular properties of the coating being applied. Spray applicators must learn about the properties of certain coatings and how fast they should be applied. This knowledge can then be converted into skill through training and experience, because ultimately, this skill and knowledge can result in more accurate mil-build (coating thickness applied to substrate). As a result of inappropriate mil build, coating defects can develop in the forms of corrosion or poor abrasion resistance. Thus, an accurate and consistent mil-build is the most important factor affecting coating performance and durability of the complete coating system. Techniques that can be taught to improve consistency include identifying and producing the proper fifty percent overlap with each spray pass and maintaining an orientation of holding the spray gun perpendicular to the substrate.

Figure 1. An Anti-Terrorism Bomb Blast Protective Coating is sprayed onto the Interior Walls of an Air Force Base facility. (Photo taken by Airman 1st Class Nicholas Pilch and provided courtesy of the US Air Force)

All of these factors play a pivotal role with regard to the end product and the coating quality. Beginning at the preparation stage and continuing through the entire application process, the implementation of these techniques assure an efficient, accurate and consistent finish on materials. Perhaps the best way to quickly achieve this level of proficiency is through proper and effective training. However, to supplement and enhance training, several technologies have been developed to help coating applicators cultivate and maintain proper techniques for the coating application process.

LASER-GUIDED SPRAY GUN ATTACHMENT

Efficiently using raw coating materials can lead to significant savings when large quantities of coatings are required. This leads to the question of how can coatings be used more efficiently? One answer to this question is maintaining a proper spray gun distance. When spray guns are too far away from the substrate there is an increased likelihood of coating over-atomization†. One result of over-atomization is that the coating material can bounce off the substrate, which results in wasted material. Improving the consistency with which substrates are coated can reduce the occurrence of several problematic coating application results. Two of the most easily recognized results of an inconsistent finish are sags and light spots. Sags result in areas with a wet paint film build that is overly heavy causing the paint to drip down the surface, and light spots can cause certain coatings, such as chemical agent resistant coatings (CARC), to lose their effectiveness. Often these problems can be attributed to a change in the distance the spray gun was held from the substrate.

The Iowa Waste Reduction Center (IWRC) has combined available technologies to help applicators mitigate these problems. To ensure applicators maintain a consistent distance between the nozzle of the spray gun and the substrate, IWRC created a special laser device which attaches to any spray gun. The laser-guided spray gun attachment utilizes a class 3A device laser beam‡ that passes through a beam splitter producing two separate beams, which are projected onto the substrate being painted, as shown in Figure 2. As the applicator moves the gun toward or away from the substrate the two laser dots move in relation to each other. When the two laser dots converge and result in one dot on the substrate, this indicates to the applicator that the paint from the spray gun is traveling the optimal distance from the spray gun tip to the substrate. When the distance between the spray gun and substrate changes, the laser dot will separate from one dot to two dots. The spray gun settings can be adjusted by an experienced applicator to determine the optimal distance at which the lasers converge. This visual feedback serves as an aid for maintaining a consistent finish and uniform thickness on the substrate and in the long-term helps prevent coating failure.

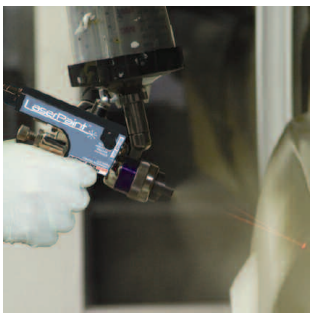

Figure 2. Two Laser Beams Help the Coating Applicator Maintain Proper Distance from the Substrate and Keep the Coating on Target.

An additional advantage of this system is that applicators have been able to gauge exactly where the paint is going to land using the converged dots of the laser to target the gun. Increased control over where paint is sprayed can decrease the amount of paint sprayed off of the edge of the part and improve transfer efficiency§. Increased transfer efficiency leads to a reduction in volatile organic compound (VOC) emissions, hazardous wastes and ozone causing air pollution. IWRC data have shown that transfer efficiencies can be increased by almost forty percent when using this laser-guided spray gun attachment.

In addition, the laser attachment has demonstrated another advantage in that it has helped to more precisely control overlapping spray passes at the optimal fifty percent overlap. When a fifty percent overlap is achieved, coating application defects such as tiger striping** are eliminated.

The laser-guided spray gun attachment has been shown to improve the technique of spray applicators, while decreasing costs, materials, waste and time. With this new technology, spray applicators have demonstrated that they can consistently apply a high quality finish while reducing the environmental impact.

TRAINING

Effective training is rarely provided to commercial and industrial spray applicators. In most cases, an applicator is handed a spray gun with minimal knowledge and is forced to either learn on their own through trial-and-error or while watching their peers. This lack of standardized fundamental training can lead to a significant gap in the knowledge and skill level of applicators.

Extensive hands-on training is necessary to help applicators understand, practice and become proficient with proper coating application techniques. Traditionally, however, there have been many drawbacks to providing effective hands-on training to coating applicators. These typically include the amount of time, labor, space, material, hazardous wastes, and safety precautions that are required, as well as the cost that is incurred when conducting training. Such obstacles and expenses lead to less than optimal rates of training for incoming spray technicians. Consequently, these coating applicators are often trained on the job, possibly learning bad habits from more experienced applicators, who also may not have been trained properly. To help overcome some of these obstacles and costs a special training program was created to address the issues and provide the DoD with a resource for training incoming and experienced applicators.

A New Approach to Training

The Spray Technique Analysis and Research for Defense (STAR4D®)†† program was developed and implemented to provide individual, hands-on training to military spray applicators, focusing on developing proper techniques as well as improving efficiency and reducing waste. This program, which was established by IWRC, has provided military personnel with the education and resources needed to develop quality painting techniques. The program has utilized state-of-the-art technologies and hands-on painter training to not only help improve coating durability and performance, but also to save money and resources by implementing waste reduction initiatives.

This training program for military personnel has taught applicators how to effectively spray specific components, equipment, vehicles and surfaces to maximize coating efficiency and minimize environmental pollution. Sample training results, which are shown in Table 1, compare the transfer efficiency of coating applicators before and after training. Other data are also shown in the table, including the amount of environmentally harmful VOCs released. The test results show that the average transfer efficiency for 254 students improved from 56 percent to 66 percent after training. Additionally, the amount of coatings is shown to have been reduced by 13 percent among the students trained. [1]

Military personnel have traveled to the facility in Cedar Falls, Iowa, to learn advanced spray techniques, master new technologies and examine alternative technologies that allow spray applicators to improve quality. As a result, military spray technicians from 65 sites in 40 states and territories have received instruction in the form of training, equipment and waste reduction advice.

The program educates trainees about the fundamentals of coat-

Table 1. STAR4D® Results from Training Classes to Date [1].

No. of Students: 254	Pre-Training	Post-Training	Difference	Percent Change
Transfer Efficiency	55.56%	66.12%	10.56%	19.01%
Amount of Coatings Used (gal)	0.15	0.13	0.02	13.33%
Amount of VOCs Released (lbs)	0.45	0.39	0.06	12.57%
Amount of Coating Material Used per Thickness Applied (gal/mil)	0.06	0.05	0.01	16.67%

ings and spray techniques. Furthermore, in order to give applicators training that was relevant to their job, the program makes every attempt to use the same coatings and equipment that they typically use on-site (Figure 3). The training staff also demonstrates some of the new or existing technologies which may prove more efficient for their process.

During the training course, applicators go through a mix of classroom, hands-on and simulation training. A pre-test and post-test are administered which allows the trainees to see their growth and improvements from the first day to the last. By focusing on strategies and techniques that enable military spray applicators to use less material and improve spray technique, applicators are able to return to their paint facilities and produce a quality finish while most likely lowering the costs and environmental implications associated with painting.

Coating Application Research

In addition to training, IWRC has been conducting numerous studies and research relating to painting and coating operations. In response to anticipated local and federal restrictions on volatile organic compound (VOC) and hazardous air pollutant (HAP) emissions, the DoD is in the process of replacing its current solvent-borne chemical agent resistant coatings with water dispersible CARC (WD-CARC II), which are in compliance with these restrictions. The STAR4D® training program is currently providing assistance in examining the compatibility of the new types of WD-CARC II and is investigating the possible use of infrared curing in order to reduce potentially problematic cure times. Supplemental to these applied studies on the performance of newly developed CARC, a cost analysis regarding the placement of solvent-borne CARC to WD-CARC II was recently completed for the DoD. Studies of WD-CARC II dry times have also been conducted for the National Guard Bureau in the past year. IWRC has also developed a data compilation containing CARC information for the Army. This CD has been distributed to various military bases across the United States and is continually being updated with new information.

Figure 3. A Military Technician Practices Proper Spray Technique on the Hood of a Vehicle.

IWRC has spent the past two years developing a standardized painter training course for Air Force spray applications. In its entirety, the course consists of instructor manuals, student manuals and presentations for 13 units that encompass the process of coating application. Six military bases were visited with the purpose of determining the factors and problems that needed to be addressed and incorporated into an effective training program. Based upon the research at the bases, the IWRC designed the program to meet those needs and developed the instructor manuals accordingly.

Other Coatings Projects and Training

IWRC is also involved in projects and studies that involve the use of black lights for the inspection of coating mil-build and the development of a painter certification course. By discovering new ways to examine acceptable mil-build, such as using a black light, a reduction in corrosion could result by reducing the occurrence of light spots. Additionally, the goals of the painter certification course will be to educate and help select spray applicators for the DoD.

The program offers an interactive website to complement the training program. The site, www.star4d.org, serves as a centralized location where painters of the US Armed Services can find useful information.

Virtual Spray Training

To eliminate many of the drawbacks of conventional spray application training, an innovative approach was developed that utilizes virtual reality technologies such as simulated paint and surfaces. Spray applicators are now able to view and interact with real spray application equipment while simulating the actual application process onto a virtual surface, as shown in Figure 4. The conventional training requirements of a paint booth, safety equipment, solvents or a regulatory permit are no longer necessary. The time spent to prepare the surface, mix the coatings and cleanup are also factors that no longer must be considered in the training process.

Simulated spraying is very similar to actual spray application but with additional benefits. The virtual training system uses a real spray gun which is uniquely instrumented to allow applicators to control flow rate and fan size in the same manner as they do on other spray guns. Those factors can also be displayed on the simulator screen to enable applicators to completely understand how the spray gun operates.

How the Virtual Training System Works

When the spray gun trigger is pulled, the position and orientation of the spray gun is automatically tracked in relation to the virtual surface. A software program translates the data input and communicates it to a projector which then displays the spray pattern onto the screen.

Along with the benefits of learning the spray gun operation, applicators are also provided with instantaneous feedback

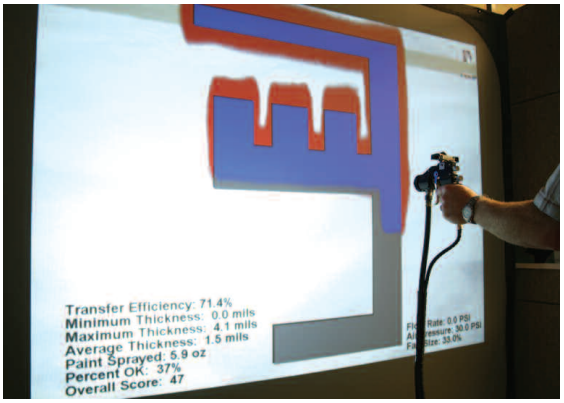

Figure 4. **Demonstration of the Virtual Spray Application Training System.**

Figure 5. **Two Viewing Modes of the Virtual Training System: Single Color Mode (Left) and Accumulation Mode (Right). Various Thickness Levels Are Visible in the Accumulation Mode.**

regarding their spray pattern and overall application. Mil-build average, ounces of paint sprayed and elapsed time spent spraying are also displayed on the screen. Regarding the actual application, transfer efficiency and overspray are also displayed. All of these factors combine to give applicators a quantitative assessment of their performance and ultimately the overall effectiveness of the training.

While all of the factors explained thus far are important, possibly the most useful display factor is the use of two different paint accumulation modes: the single-color and the multi-color accumulation mode (Figure 5). Single-color paint mode is an approximation of the actual appearance of paint. In this mode, shades of a single color are used to indicate paint thickness. In multi-color accumulation mode, multiple shades of three colors are used to indicate the thickness of the paint. In this mode, the surface color represents an area with no paint. Shades of blue represent values below the minimum thickness setting. Shades of green represent values within the minimum and maximum target thickness range. Shades of red represent thickness values that exceed the maximum target.

Advantages

This system has allowed for realistic hands-on painter training to be conducted in a more suitable setting. For example, the virtual training can be conducted in a classroom with more students compared to conventional training. The instructors can provide demonstrations encompassing spray gun setup and proper application and then supervise the students as they practice in the same room. This allows the instructor to identify strengths and weaknesses of each trainee.

The virtual spray application training is beneficial because applicators are presented with an unlimited amount of practice parts and materials while completely eliminating the byproducts of hazardous waste or air emissions. Applicators are able to explore coating application and accumulation in an entirely new way, while improving the motor skills necessary for applying high performance coatings appropriately.

SUMMARY

The military spray application training program, STAR4D®, at the IWRC continues to meet the needs of military spray applicators by continually updating their knowledge-base and increasing their technological capabilities through tools such as the laser-guided spray gun attachment and the virtual training system. With the help of this program and these technologies, the DoD continues to properly train and educate spray applicators. As a result, coatings applied to real-life military systems and equipment will be of higher quality to ensure these systems are ready in the time of need.

NOTES AND REFERENCE

* Lead is the distance between the point where the material leaves the part and the point where the spray gun trigger is released; lag is the distance between the point where the spray gun is triggered off of the part and the point where the material leaving the spray gun lands on the part.

† Over-atomization results when the paint droplet size becomes too small and does not adhere or bounces off the substrate.

‡ A class 3A laser is one that is produced for continuous operations but does not require operator training.

§ Transfer efficiency is the amount of coating material deposited on the substrate divided by the amount of coating material sprayed.

** Tiger striping is a defect that occurs as a result of an inconsistent film build.

†† STAR4D® is a registered trademark of the Iowa Waste Reduction Center.

[1] STAR4D® Training Class Database, Iowa Waste Reduction Center, University of Northern Iowa, http://www.star4d.org/database.cfm.

Lea Ann Schellhorn is a member of the staff at the Iowa Waste Reduction Center (IWRC). As a part of Iowa's 1987 Groundwater Protection Act, the IWRC was established as a service of the University of Northern Iowa (UNI) in Cedar Falls, Iowa. The IWRC receives state and federal funding to provide small Iowa businesses with the guidance and resources necessary to keep up-to-date with the constantly changing environmental regulations. A portion of the Center has focused on the painting and coating industry for over 10 years. Not only is training conducted on-site, but the staff continuously keep up-to-date with knowledge and advancements in the industry. The IWRC is continuously striving to expand their resources and services to provide equipment and tools to assist spray technicians in their day-to-day routines.