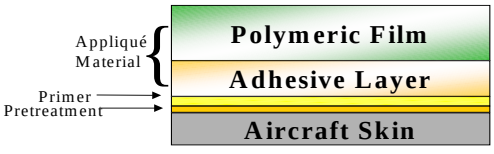
Appliqué Laboratory Testing

Background:

Aircraft coating systems perform a variety of functions--most importantly corrosion protection and prevention. Current methods of applying and removing coating systems from military aircraft at DoD aerospace facilities generate over 100 million pounds of hazardous waste per year and emit enormous quantities of volatile organic compounds (VOCs) and hazardous air pollutants (HAPs). Cost for disposal and/or treatment of these hazardous materials is high, and recent legislative mandates restricting the allowable VOC and HAP emissions at aerospace reworking facilities necessitate the use of environmentally-controlled facilities, in order to control the emissions, leading to increased operating costs of applying and removing coating systems from military aircraft.

Generally, an aircraft is stripped every four to six years during its programmed depot maintenance (PDM) cycle and undergoes a scuff sand and overcoat at the field level on an average of two times between each PDM cycle. Maintenance personnel must continually touch-up exterior finishes at the field level for cosmetic or repair reasons. This approach leads to a significant usage of material and human resources and more hazardous waste. In addition, the accumulation of paint from these frequent "touch-ups" reduces fuel and payload capacity thereby affecting mission readiness. The health risks associated with paint and depaint activities prohibit the performance of any concurrent aircraft maintenance activities subsequently adding additional ground time and non-operational aircraft status. The aforementioned issues culminate in increased life cycle costs for DoD aircraft.



Early investigations of environmentally-friendly paint alternatives indicate that the *Appliqué* technology provides a non-VOC, zero-weight growth, easily replaceable, topcoat with optimum corrosion, appearance, and survivability characteristics required of a coating system. The *Appliqué* technology consists of an extruded fluoropolymer sheet with a pressure-sensitive adhesive, which is protected by a liner that's removed immediately before application. *Appliqué* eliminates the traditional method of topcoat application requiring the use of spray guns and

environmentally compliant hangars/buildings, and the production of environmental waste. *Appliqué* also reduces the uncertainty of curing since the topcoat is already cured and only the adhesive cure must be monitored. The adhesive cure cycle is a matter of hours instead of a matter of days for traditional paint coatings. In a similar manner, the field repair is simplified.

Laboratory and proof-of-concept flight demonstrations (on the Navy F/A 18 and S-3, and the Boeing F-15 and F-16) show the feasibility of the application Several applique' projects have been accomplished or are being accomplished:

- proof-of-concept on fighter (F-16 by the F-16 SPO and ASC Engineering) and on cargo aircraft, (e.g. C-130 by Lockheed and AFRL/CTIO),
- materials characterization,
- specification development, (by National Institute of Standards and Technology (NIST))
- commercialization of the technology, (by NIST)
- and assessment of environmental impact. (F-16 SPO and ASC Engineering and C-130 by Lockheed and AFRL/CTIO)

All of these projects serve as the basis for CTIO's Appliqué Laboratory Testing project. Previous studies have not explored the adhesion of the A*ppliqué* to the various aircraft coating systems nor address the repair and maintenance methodology. The CTIO project plans to address these issues, thus complement the aforementioned projects.

Project Sponsor/Customer: Air Force wide
Period of Performance: Mar 99 – Mar 01

Objectives:

This project was developed to evaluate appliqué as a potential alternative to sprayed coatings for aircraft topcoats. CTIO has interfaced with the interested Major Commands (MAJCOMs), System Program Directors (SPDs), and Air Logistic Centers (ALCs) to consolidate their requirements and plan for laboratory evaluation of appliqué technology. CTIO worked with the Department of Defense (DoD) appliqué team to develop a consolidated list of performance issues, test methods, and acceptance criteria. CTIO has performed tests and flight evaluations with Air Force depot and field level personnel for the purpose of integrating the appliqué corrosion protection systems into the AF maintenance process. Specific project objectives include:

- Determine the level of adhesion of the two series of *Appliqué*, 500 & 1500, perforated and non-perforated, to the C-130 aircraft coating systems.
- Determine the effects of the primer cure time on adhesion of the *Appliqué* to the primer and to the substrate.
- Determine the corrosion inhibition potential and perform EIS analysis of both series of *Appliqué* with perforated and non-perforated types on chromate conversion coated, Sol-Gel, and chromated primer surfaces.
- Determine adhesion of *Appliqué* to topcoat and vice versa at the seams and edges where *Appliqué* cannot be applied and the areas adjacent to the *Appliqué* that must be conventionally painted. Additionally, determine the effects of over-spray on the adhesion of *Appliqué*.
- Determine the best removal technique(s) for *Appliqué* at the field level.
- Determine the best repair methodology for areas where contaminants such as hydraulic fluid, oil, and jet fuel have seeped through the *Appliqué* seams or holes in the substrate. Additionally, determine the extent of the area to be removed when reapplying *Appliqué* to a contaminated area.

Status:

Adhesion testing of the *Appliqué* 500 and 1500 series (perforated and non-perforated), and the three predominant types of adhesives (Series 52-1, 52-2, and 52-3) has been initiated. Additionally, the effects of cure time of the primer on the adhesion of the *Appliqué* to the primer and to the substrate for these samples has been determined. Pull testing results for the Primer Cure Time versus Adhesion for Batches 1-4 are being examined.

Primer Cure Time and Adhesion Comparison testing has been completed. Corrosion test panels have been reviewed and photographed upon completion of 2000 hours of Salt Fog exposure. All Electrochemical Impedance Spectroscopy (EIS) panels are being exposed in the Q-Sun Xenon-Arc Weatherometers. Spectroscopic testing has been performed prior to and after 1000 hours of exposure. The final spectroscopic testing and EIS testing, following the cumulative 2000 hour exposure, are currently being performed. Corrosion Testing has been completed with the panels being exposed in Salt Fog for 2000 hours. Panels were cleaned and wiped, and a visual analysis was performed before removal of Appliqué. The perforated Appliqué panels with both Sol-Gel treatments and no primer showed extreme corrosion. Once this visual inspection was completed, Appliqué was removed from the lower half of each panel and

the surface was inspected for signs of corrosion. There were visible signs of primer degradation under each perforation on all surface treatments. It was also apparent corrosion initiated from the perforations as well as the scribe on the panels treated with both Sol-Gels and no primer. Photographs were taken of each panel before and after the Appliqué was removed. Q-Sun exposure and EIS Analysis continues. Testing is planned to be completed on 6 Apr 01.

Project Plan: Approved May 00
Test Plan: Approved May 00
Final Report: Planned draft completion late May 01
As of Date: 20 Mar 01