Appliqués for Corrosion Protection in a Tropical Environment

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Appliqués were placed on several structures at the Pacific Missile Range Facility in Kauai, Hawaii. They were periodically inspected and compared to the original paint coatings. The appliqués provided excellent corrosion protection. In some cases, the original paint did not provide adequate protection, requiring either repainting or replacement of the structure.

Protecting critical assets from corrosion in aggressive environments, such as tropical coastal locations, is an ongoing challenge. Paints are the most common means of corrosion protection and can be highly effective for some time, but eventually degrade and must be repaired or replaced. Coatings in tropical marine or coastal locations are subjected to intense ultraviolet (UV) radiation and constant salt spray. These conditions generally contribute to the premature failure of conventional coatings from modes such as osmotic blistering and chalking. Coating holidays or other defects allow rust to start and spread by undercutting the coating. Paint removal and recoating frequently involve the release of volatile organic compounds (VOCs) or generation of other hazardous materials that must be disposed of properly. Furthermore, in tropical, coastal, or marine sites, coating repairs are often difficult (i.e., prepared surfaces have to be immediately coated to prevent the surface from becoming chloride-contaminated).

Appliqué Technology

Appliqués are manufactured films of fluoropolymer with a pressure-sensitive adhesive to bond to a structure. They offer several advantages compared to paints: Because the fluoropolymer is a uniform, manufactured film, it is a very effective barrier layer without pinholes or holidays that can occur with sprayed or brushed paint coatings. The appliqué is applied by removing the release backing film and pressing against the structure, much like "peel and stick" wallpaper. As such, it is most easily applied to simple shapes, but complex configurations can often be accommodated by cutting sections to conform to the particular shape. Appliqués are ready for use immediately, with no drying or curing time required.

Osmotic blistering occurs with conventional coatings on surfaces that have

been contaminated with atmospheric chlorides. Over time, moisture permeates the coating and reacts with the surface salts, causing blistering and ultimately coating failure. Fluoropolymers attenuate permeation, thus reducing the risk of blistering. Chalking is caused by UV radiation breaking down the coating, causing a chalky appearance that is subsequently weathered away, thus exposing virgin coating and allowing subsequent UV attack. Fluoropolymers are less susceptible to chalking than other coating materials.

Appliqués were applied to parts of several structures at the Pacific Missile Range Facility (PMRF) in Kauai, Hawaii. Most of the appliqués were applied at or near a launch pad located ~200 m from the shore. This was new construction with visually pristine original equipment manufacturer's (OEM) coatings. The appliqués were applied on top of the coatings after a simple alcohol wipe to remove any surface contamination.

In all cases, the appliqués covered only a portion of the structure so a direct comparison with the OEM's coating could be made. The structures were inspected visually approximately every six months for a period of two years. Additional appliqués were applied to a high mobility multipurpose wheeled vehicle (HMMWV) in Texas, which was then shipped to PMRF.

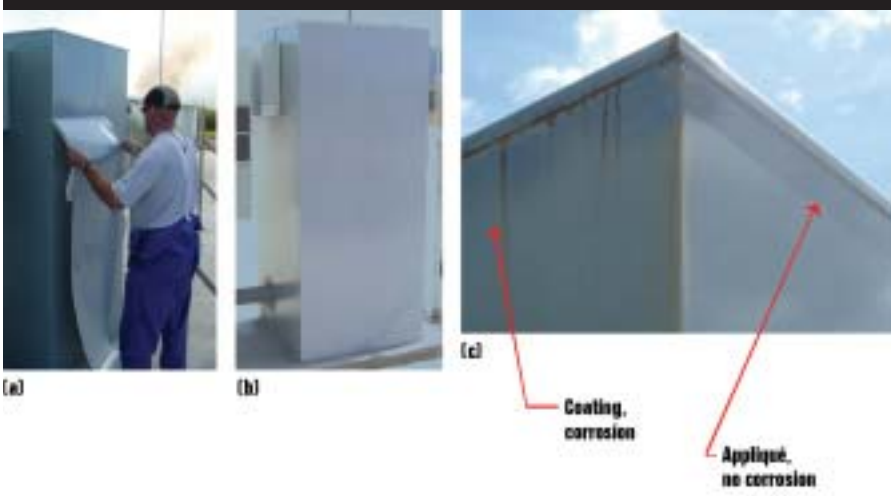
Results

In the course of the two-year study, all the appliqués performed well with no corrosion seen in the appliqué areas. In contrast, some of the OEM's coating did not provide good corrosion protection. Four examples are reported here.

Equipment Cabinet

The back side of an equipment cabinet was covered with a 3-mil (76-µm) gray ethylene-chlorotrifluoroethylene (ECTFE)

FIGURE 1



Equipment cabinet at launch site. After approximately six months, corrosion had occurred along the edges of the metal sheet. (a) September 2004, applying appliqué, (b) after application, and (c) March 2005.

FIGURE 2

East side (mountain side) of storage tank at block house without appliqué. The tank was dirty with bird droppings and rust spots until recoating. (a) September 2004—without appliqué, and (b) October 2005.

FIGURE 3

West side (ocean side) of storage tank at block house with appliqué. (a) September 2004—appliqué as installed, and (b) October 2005.

FIGURE 4

(a) (b)

Piping to fuel tank at blockhouse. The red rectangles indicate the approximate location of the appliqués. (a) September 2004—as installed, and (b) October 2005.

appliqué (Figure 1). By the time of the first inspection at six months, corrosion on the exposed edges of the roof panel and blistering of the OEM's paint were readily visible, as were rust stains down the sides of the cabinet. An attempt to ameliorate this rust had been made at one point by painting over the rust stains. No corrosion, blistering, or other deterioration were observed where the appliqué had been applied. By April 2005 (approximately seven months after installation), the corrosion was sufficient that a decision was made to replace the original cabinets with stainless steel (SS) cabinets covered by a SS enclosure.

Fuel Tank

The west side (toward the ocean) of a white fuel tank was covered by a white 3-mil polyvinylidene fluoride appliqué; the east side (toward the mountain) was left as received (Figures 2 and 3). The east side quickly became dirty from bird droppings and rust spots where the paint had failed (Figure 2). Because of its appearance and deterioration, the entire tank was cleaned and repainted between the 20th and 25th months. Small spots of corrosion were already beginning to form on the repainted areas. In contrast, the west side with the appliqué remained clean the entire time (Figure 3). Although this side likely received fewer bird droppings than the east side, the non-stick appliqué surface allowed rain to wash the droppings away to maintain a clean surface.

Piping

Sections of the piping to the fuel tank were covered with a 3-mil gray ECTFE appliqué at the same time as the tank (Figure 4). Before the initial inspection at six months, mechanical damage had occurred in some areas of the paint and the appliqué. Corrosion was readily visible in the damaged painted areas as well as some painted areas that were not damaged. This corrosion continued and worsened until the entire piping was repainted between the 20th and 25th months. At no time was there any corrosion on the appliquéd areas, whether they were damaged or not.

HMMWV

Approximately midway in the PMRF study, appliqués were applied to an electronics unit mounted on a HMMWV at Fort Bliss in El Paso, Texas. This vehicle was then shipped to PMRF and inspected during subsequent trips. A white ECTFE appliqué was applied to the top to reduce radiant heating in the tropical environment, while glossy clear ECTFE was applied to the sides to maintain the color scheme (Figure 5). A flat tan appliqué would have been preferred to match the chemical agent resistant coating (CARC) and prevent color changes (mostly darkening) due to the adhesive, but this version was not available with the short notice of this opportunity.

In some locations, paint degradation or corrosion was already apparent before appliqué application. The corrosion products were removed and appliqué patches were applied for corrosion protection.

Several observations could be made following this demonstration:

- An appliqué can be applied to real structures in the field with minimal surface preparation and in a reasonable time with no paint drying time required.
- Protrusions, such as rivets and screws, can be successfully covered by appliqués.
- Corroded or deteriorated areas can be cleaned and protected by appliqués.
- The temperature of the unit was noticeably cooler the day after the white appliqué was installed. This was especially helpful in El Paso and PMRF, as well as any other location with high average solar radiation.

The HMMWV was inspected at PMRF on October 2005, May 2006, and October 2006. Paint repair by appliqués showed excellent performance. Figure 6 shows a repaired patch with no corrosion seen on the bare metal under the appliqué. Similarly, no corrosion was observed on a scribed appliqué patch. For comparison, a tie-down loop from which the paint had been removed is shown to demonstrate the amount of corrosion expected on bare metal.

Aside from the color change or darkening, which could be prevented by matching the appliqué color to the CARC tan, the only issue needing to be addressed was coverage of complex shapes. Covering the rivets and raised areas of the HMMWV near the edges of the appliqué allowed a few places where moisture could ingress and remain. This

caused corrosion in some places, but it must be emphasized that these areas were a small fraction of the appliqué area and could be reduced or eliminated with optimum appliqué application.

Conclusions

Fluoropolymer appliqués provide excellent corrosion protection of structures in coastal tropical environments. No degradation was observed or maintenance required during the two-year inspection period of this test. In contrast, the original coating on several structures allowed corrosion and required the structures to be recoated. In one case, the structure needed to be replaced in less than one year.

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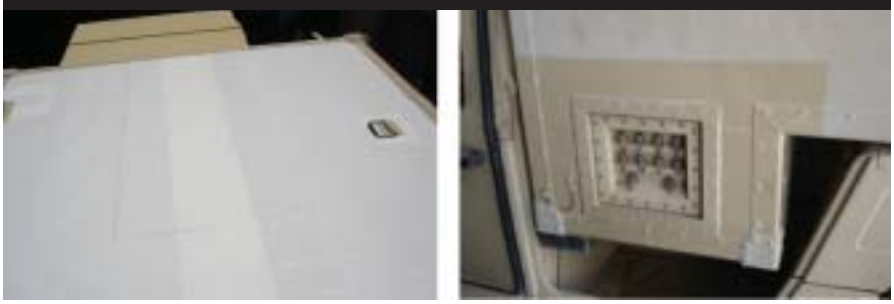
FIGURE 5



(a) (b)

Electronics unit after application of appliqué. (a) roof, and (b) October 2005—appliqué covering rivets.

FIGURE 6

(a)

(b)

(c)

HMMWV after approximately one-year exposure at PMRF. (a) overview, (b) coating repair, and (c) corrosion on bare metal.

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