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The Aluminum Association

ALUMINUM CORROSION 101

Types and Prevention

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Corrosion Types for Aluminum Parts Used in Vehicular Applications

The use of aluminum alloys for automotive applications has increased significantly in recent years. This trend is expected to accelerate due to the need for increased mass reduction in vehicles. Aluminum used in most automotive applications has excellent corrosion resistance, even in the unpainted condition. Under some conditions, however, painted or unpainted automotive aluminum can develop one of three different corrosion types:

- Galvanic corrosion
- Filiform corrosion
- Crevice corrosion

In most cases, aluminum corrosion is cosmetic in nature influencing paint retention. Corrosion of aluminum is predominantly surface corrosion and does not penetrate through the thickness of the material and does not weaken the structural integrity of the part. This short communication briefly explains each corrosion type and relevant preventative measures.

GALVANIC CORROSION

Galvanic corrosion occurs when a metal is in contact with a dissimilar metal or a non-metallic conductor (for example, carbon in mounting bushings) and the joint is exposed to a common corrosive electrolyte, such as salt water. The corrosion of the more active metal (aluminum) occurs. The most common examples of galvanic corrosion in automotive applications involve aluminum alloys in contact with bare steel (Figure 1). In this example, an uncoated steel nut was in contact with aluminum alloy sheet. The corroded region is approximately the shape of the steel nut in contact with the aluminum. The rate of galvanic corrosion is very slow, requiring many hours of exposure to an electrolyte before visible corrosion is observed.

Conditions for automotive galvanic corrosion, requires all three:

1. Contact between unprotected surfaces of two dissimilar metals—aluminum and steel
2. Corrosive liquid in joint
3. Electrical current path across joint

There are two methods for eliminating galvanic corrosion: 1.) Eliminate contact between the dissimilar metals using coating, paints or sealants; or 2.) Eliminate exposure to electrolytes like salt water by using sealers, such as adhesives, primers, and other paint coatings.

The suggested preventative measures for galvanic corrosion:

- **Use OEM recommended:**
  - Metal coatings
  - Galvanized steel in contact with aluminum
  - Coated fasteners
  - Insulating washers if specified to electrically isolate components
  - Sealants, such as adhesives, primers, and other refinish coatings for corrosion prevention between dissimilar metals

Preventative measures to minimize exposure to salt water:

- **Use of OEM recommended:**
  - Coatings and refinish materials to prevent salt water exposure
  - Sealants to prevent salt water entering the joint

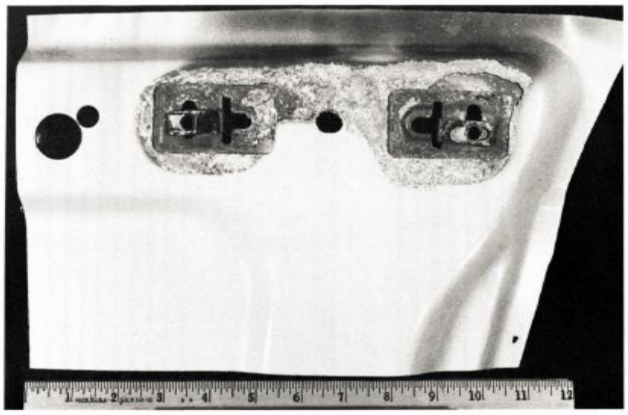

Figure 1. *An example of galvanic corrosion of aluminum coupled to steel. A steel member (not shown in the picture), approximately the size and shape of the corroded region, was in contact with the aluminum sheet.*

FILIFORM CORROSION

Filiform corrosion is a form of cosmetic corrosion that occurs on the surface of aluminum under paint, primers and coatings. Degradation of the aluminum parts is cosmetic and the corrosion attack is limited to the surface. Filiform corrosion typically results in paint bubbling and separating from the metallic surface. This form of corrosion appears as thin thread-like filaments filled with corrosion products (white powder) beneath the coating as shown in Figure 2. It typically starts around a defect in the coatings caused by stone chip, scratch or sharp cut edges, or punched or drilled holes. Filiform corrosion can remove the protective properties of the coating system. Figure 3 shows the ground surface of an automotive hood with filiform corrosion that initiated by a stone chip on the front edge of the hood.

Conditions for filiform corrosion, requires all three:

1. Painted or coated aluminum surface
2. Damage to surface coating allowing corrosive liquid to penetrate under coating
3. Presence of corrosive liquid (typically, salt water)

Filiform corrosion typically occurs in humid / warm environments and is noticeably more common in coastal and industrial areas.

Preventative measures for filiform corrosion:

- Thoroughly cleaning the surface prior to coating
- Applying OEM recommended corrosion protection
- Eliminating surface defects (e.g., pores, mechanical damage, air bubbles, insufficient coverage, etc.)
- Applying OEM recommended refinish materials

Painted aluminum parts with filiform corrosion can be repaired by removal of the coatings and corrosion by sanding, followed by refinishing with OEM recommended refinish materials.

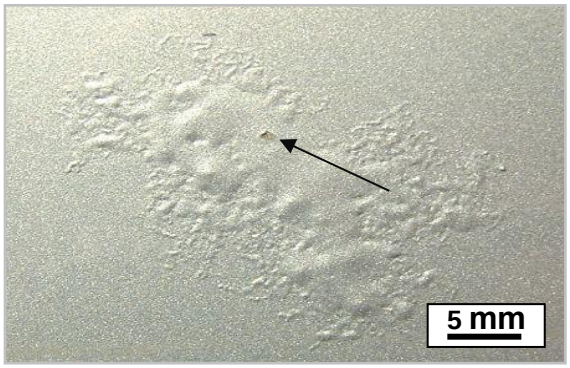

Figure 2. *Filiform corrosion attack on Aluminum part from a vehicle in service. The arrow points to the paint defect where the corrosion initiated [1].*

Figure 3. *Ground surface after paint stripping [1].*

CREVICE CORROSION

Crevice corrosion of aluminum can occur in a joint in contact with another material when a corrosive liquid (salt water) is present between the two surfaces in contact. Crevices (narrow openings) at mating surfaces can collect and retain moisture that may lead to corrosion. The mating surfaces can be aluminum to aluminum, aluminum to steel, or aluminum to plastics. Higher temperatures, salt content and other factors can accelerate the corrosion. Measures that eliminate or seal crevices, greatly reduce the risk of crevice corrosion.

Conditions for crevice corrosion, requires:

1. Crevice (thin joint) between surfaces of two materials—aluminum, steel, plastic
2. Corrosive liquid in joint (typically, salt water)

Crevice corrosion is usually shallow corrosion appearing as pits or etching patterns. It can be found under gasket fittings, welded lap joints, overlapping metal seams, folded or formed sheet hems.

The suggested preventative measures for crevice corrosion:

- **Use OEM recommended:**
  - Corrosion resistant primers, sealers and other refinish materials on aluminum surfaces
  - Seam sealers to prevent water entry into joint

References:

1. G M Scamans, A. Afseth, G E Thompson, J Liu and X Zhou, “Aluminum Automotive Closure Sheet Corrosion”.