A SERIES OF ARTICLES ON CORROSION

As we grow older, we instinctively reach out for ways to slow the process down. We want to stay as young and as productive as we can for as long as we can. It's called anti-aging and the first step is to find out where the hidden causes for future health failures lurk—and what to do about them.

It's the same for airplanes as it is for people. If we don't help our beautiful beloved fleet of Bonanzas and Barons and Travel Airs resist aging, we place them in real danger of wasting away from out-of-sight, out-of-mind corrosion.

In this and future installments, ABS member Dennis Wolter provides a clear and comprehensive view of aircraft corrosion...how and where to find it, causes, remedies, and the best way to keep out in front of the problem.

His expertise on the subject of aircraft corrosion is impressive and authoritative. Thirty-plus years in the aircraft renovation business has made him an "unwitting expert" (his description) on the detection and removal of corrosion, particularly in the cabin. His willingness to answer the key questions most owners need to know about corrosion is generous and appreciated.

We're sure you'll find the series an interesting and invaluable guide for keeping your airplane younger longer. We hope it will also inspire other Society members to share their own special ways of dealing with the advancing age of their airplanes.

—The Editor

What is CORROSION?

BY DENNIS WOLTER, AIR MOD
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The answer to that actually comes in two parts. The first part is pretty simple. Corrosion is a visual anomaly that you see on the surface of a piece of metal or an actual dimensional deformity caused by corrosion inside the metal, i.e. a white powder on the surface that when removed reveals a pitting and deformation of the metal.

The second part of the answer is that corrosion is a degradation of the metal caused by attack from external contaminants and/or electron flow that accelerates the metal's return from an alloy back to its basic elements.

This is so complex that the FAA takes eight pages in AC 43-4A, chapter 2, to discuss the subject. (This document is available on the Internet if you are interested.) Much of the applicable technical information in that FAA manual will be presented in this series.

What causes corrosion?

To understand corrosion, it is important to realize that it is a natural phenomenon. All metal alloys want to return to their original state; they want to break down to the individual base metals that were combined to make up the alloy. Let's start here with the two most common causes of corrosion.

Corrosion is a natural phenomenon. All metal alloys want to return to their original state; they want to break down to the individual base metals that were combined to make up the alloy.

The first is external or surface contamination. An extreme example would be to put strong sulphuric acid on a piece of bare aluminum. There would be quite a show of bubbling and hissing and noxious vapors, and once the acid was rinsed off, there would be evidence of severe and rapid damage to the surface of the metal in the form of pitting and discoloration. Long-term exposure to salt, industrial pollutants and moisture can cause the same problem, although it may take years to have the same effect.

The second cause of corrosion is electron flow, or galvanic action. In the case of aluminum, several dissimilar metals are combined to make one alloy. The manufacturing process of aluminum is not perfect, therefore a given piece of aluminum alloy can have slightly different metallurgical contents in different areas of a given sheet, causing electrons to flow from one area to another.

Almost everything in the physical world has an electrical potential. This potential is not the same for all materials and, when differing materials come in contact with one another, electrons will flow based on the electrical potential of that material and its ability to retain, resist or propagate the flow of electrons. As

electrons flow through an alloy, the metal breaks down—both at the surface and internally—and the result is corrosion.

Compounding the problem in an airplane is the fact that this assembly of parts is made of many different alloys—steel crankshaft, lead and silver engine bearings, bronze landing gear bushings, chrome shock components and, of course, the aluminum structure. They all combine to make this beautiful object a very complex electron host.

What are the different types of corrosion?

SURFACE CORROSION. (Figures 1 and 2) This is caused by the natural oxidation process of aluminum and the reaction of aluminum to external contaminants and, of course, electron flow.

The ability of aluminum to oxidize is the very thing that keeps it from rusting, and one of the main reasons for its use in airplanes. Anyone who has ever had a bare metal polished airplane knows that the beautiful shine is short-lived. Two days after polishing the airplane, you can re-buff it with an aluminum polish rag and the rag will turn black as it removes oxidation from the skin that has built in that very short time. Left unpolished, the surface will begin to lose its luster and develop a thin white powdery coating. Left indefinitely, it will start to pit and degrade the aluminum.

Surface corrosion is very much accelerated by moisture, such as humidity and/or polluted rainwater. It is important to realize that, when water mixes with certain contaminants, it can become an electrolyte that increases electron flow and corrosion.

FILIFORM CORROSION. (Figure 3) This is corrosion that develops underneath a coating such as paint. It is generally caused by contaminants that were left on the surface or trapped between two mating surfaces before the paint was

Figure 1—Surface corrosion caused by moisture and airborne contaminants attacking an unpainted bare aluminum surface.

Figure 2—Surface corrosion exacerbated by a hydroscopic glue being applied to a bare aluminum surface.

Figure 3—Early stage of filiform corrosion. Notice irregular swelling caused by corrosion trapped under the paint.

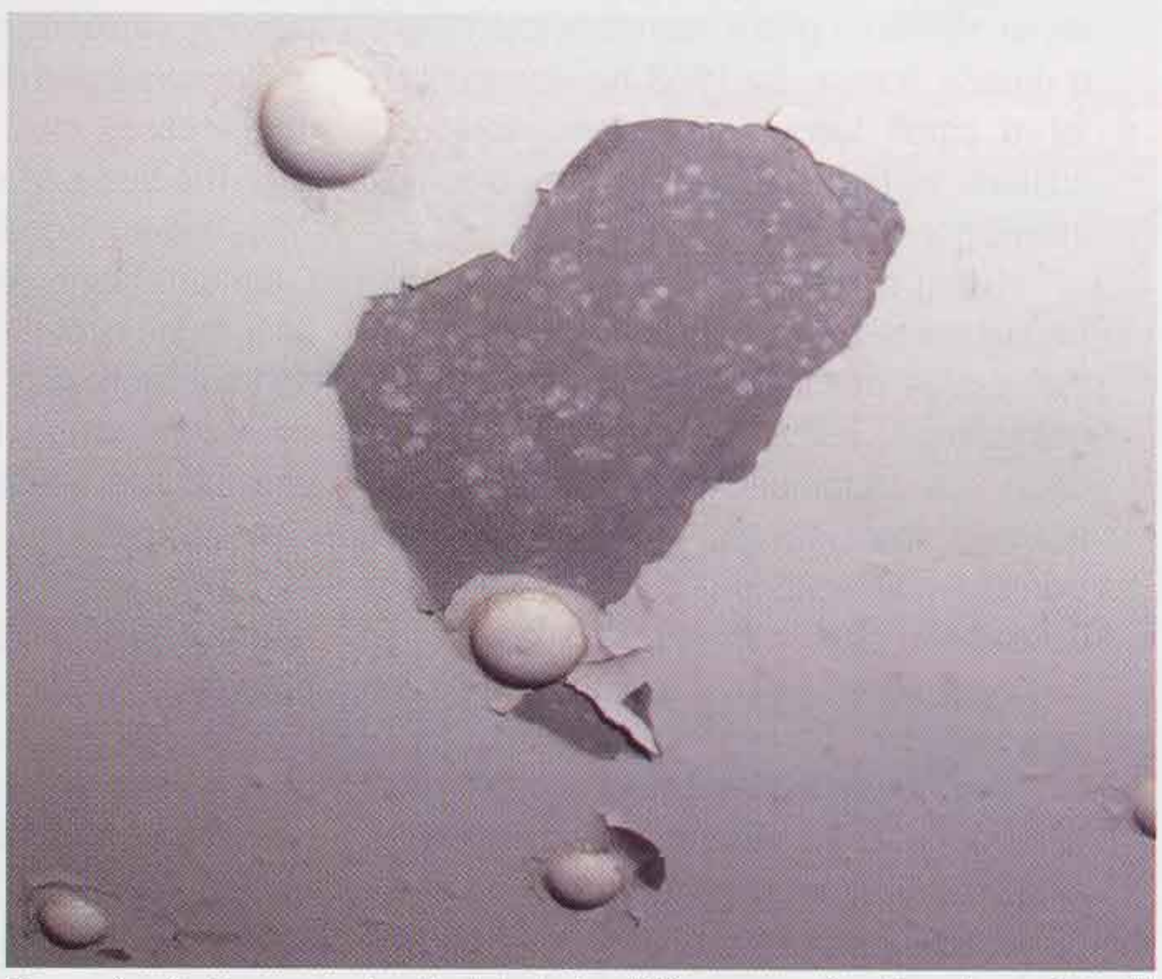

Figure 4—Surface corrosion that started as filiform corrosion, then the paint split open and surface corrosion spread at will on the skin's surface.

applied. Once trapped by the paint, the corrosion develops and has the appearance of a spidery growth or a lakebed pattern under the painted surface.

FRETTING CORROSION. (Figure 4) This is corrosion resulting from the normal causes of corrosion exacerbated by the friction when two surfaces scrape against one another. It is common to see this where cowlings vibrate against airframes, doors rub against door jambs, etc. The oxides form a powder that becomes an aggregate that accelerates the corrosion of the material as the parts rub together and mechanically force the corrosive oxides into the metal.

INNER GRANULAR CORROSION. (Figure 5) This is corrosion that doesn't react with surface contaminants but is caused primarily by differential metal content of the alloy, or a contaminant that became imbedded in the alloy as it was being manufactured. These dissimilar materials cause a very high level of inner electron flow (galvanic action) in the metal. The result is the formation of internal corrosion and oxidation, eventually making the metal swell as the pressure from the inner granular corrosion tries to push the molecules apart. At a very advanced stage, the metal begins to crack and split open, revealing the presence of powdery gray oxide.

Figure 5—Inner granular corrosion

What are the various stages of corrosion and what does each look like?

The first stage of corrosion shows up as a darkening of the metal. You will notice it when a polished bare metal airplane sits outside and begins to look dull, or when you remove some glue that was used to hold insulation against the inner surface of an outer skin and the metal under the glue has turned dark.

The second stage is the presence of visible aluminum oxide as a gray powder or crust on the surface of the metal, or under the surface of the paint in the case of filiform corrosion. In the case of inner granular corrosion, the first and second stages may only be detected by precision measurement of the component to reveal swelling, or by high-tech nondestructive testing method.

The third and most advanced stage of corrosion exists when the crusty oxidation is removed revealing severe pitting, holes in the metal surface, or cracks caused by inner granular corrosion.

ABOUT THIS CORROSION EXPERT:

Dennis Wolter says he has been crazy about airplanes since early childhood. He began learning to fly in 1959, paying for it by washing airplanes and assisting an airport mechanic with metal and fabric aircraft repair. He had a pilot's license before he got a driver's license. By 1963 he was working for a small local airline doing interiors, custom instrument panels and avionics installations.

Using college co-op and aviation jobs, Dennis earned a bachelor's degree in industrial design at the University of Cincinnati, graduating in 1969. The summer after graduation, he obtained an FAA mechanic's license, then taught engineering and aviation maintenance at a local community college. He also maintained a consulting business, designing interiors and paint schemes.

Dennis started Air Mod in 1973 at the Clermont County Airport, doing interiors, paint, instrument panels and many custom mods using FAA field approvals. From the beginning he specialized in Bonanzas and became active in the American Bonanza Society. He exhibited at his first ABS convention in 1974, and shortly thereafter began giving technical talks and seminars.

After three years, his company stopped painting airplanes, moved to Lunken Airport, and concentrated on interior renovations and modifications, much of it corporate work.

The business continued to grow in the '90s, and Air Mod built a new facility at the Clermont County Airport in 1994, relocating back to the airport where they started next to Sporty's Pilot Shop. At that point, the company moved away from corporate aircraft and focused on the owner-flown airplanes Dennis loved.

With wife Cynthia, and 10 dedicated employees, Dennis's Air Mod team completes approximately 40 renovations each year.

In 1999 Dennis became an IA, and is now involved in many new facets of aircraft renovation as they work on older and older airplanes. "In the future," he says, "dealing with this aging fleet is our next big challenge."

Dennis and Cynthia Wolter

Is aircraft corrosion a nuisance or is it a major problem?

That depends on how long it is left untreated and where it is. Probably the first encounter a person has with minor corrosion comes from the electrical system, where a very small amount of corrosion can cause a definite electrical problem.

Think of a connection for a ground wire circuit where a wire is hooked to a grounding terminal that allows the airframe to become the electrical conduit for almost every circuit in the system. Just at the point of contact, at least three different metals come together: the steel metal fastener, the copper terminal and the aluminum airframe. Add a little moisture in the form of humidity, maybe a little salt from your vacation in Florida last summer, and a long winter's nap in a damp hangar, and there is ample opportunity for corrosion to form between the dissimilar metals.

Aluminum oxide causes resistance at the point of contact resulting in a non-functioning electrical component, or worse, an intermittently functioning electrical component that can be a troubleshooting nightmare.

Minor corrosion on the structural parts of the airplane is certainly not a problem until the element of time comes into play, allowing the corrosion to eventually eat into the material and weaken the structure.

If left alone, can corrosion degrade its host structure to the point of failure?

Yes, absolutely. No situation proves this point more graphically than the problems Beech owners have had with those wonderful magnesium control surfaces. Being a high-grade alloy, magnesium is very prone to corrosion, especially when combined with dissimilar metals.

If noticed and arrested quickly, all that may be necessary is stripping and properly treating the surfaces prior to refinishing. Left to corrode too long, the metal becomes pitted. If the depth of the pitting is more than 10 percent of the thickness of the metal, the metal surface must be replaced or reinforced. If severe corrosion has occurred to the point where there are holes or cracks in the skins, the surfaces may be so structurally compromised as to fail within the performance envelope of the airplane.

Subsequent installments will address specific corrosion problems common to the Bonanza/Baron family of aircraft, analyzing its cause and detailing proper repair as well as prevention.