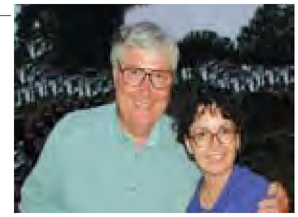


Corrosion

By Dennis Wolter

While the seats are being sewn and mounted in the sewing room, a lot is happening in the hangar. The airplane is now completely gutted and fully exposed. I know I indicated last month that we would move on to side panels, but first we need to address a few important issues. We are now ready to clean the interior cabin skins in preparation for chromating the entire inner cabin. Unfortunately, before that zinc chromate is applied, we're going to have to deal with the condition of the aluminum.

I would like to get up on my soap box and discuss the somewhat complex and extremely important subject of corrosion. If left untreated, the most irreversible threat to the longevity of these airplanes we so love is corrosion. When most of the airplanes we own were built, industry in America (Cessna included) was operating in "planned obsolescence" mode. Product marketing and production costs were a higher priority than long term durability. The mindset at the time was that these airplanes would be recycled in ten or fifteen years, and corrosion proofing was not a major concern. Well, my 172 is 33 years old and counting. Cessna definitely built a sturdy airplane, but the insidious nature of corrosion is beginning to rear its ugly head.

If there is any part of this series of articles that applies to every Cessna out there it's this subject of corrosion. If you have no intention of installing a new interior or if you just had your interior redone, read at least this part of the series and do the recommended inspections. Even if you've been told by your mechanic that your airplane is corrosion free, chances are likely that you will uncover some level of corrosion in the cabin area if you follow the suggestions we will present in these articles.

In the course of doing about 40 interiors a year at our shop (probably 20 of which are Cessnas), we get a very close look at sensitive, corrosion prone areas. In the past three years we have found only one Cessna 172 and one Beech S35 that I would consider to be corrosion free. The Cessna had lived in Arizona all its life, and the Bonanza was a lifelong resident of northern Minnesota. Both situations were dry climates with clean air. At the other end of the corrosion scale was a float-equipped 206 we took in from Michigan. The owner relayed to me his mechanic's insistence that the airplane was corrosion free. I unzipped the spanwise headliner access, pulled down the original fiberglass insulation and found a mess. The picture says it all. On a scale of 1 to 5, I would rate this level of corrosion a healthy 4+. More on the clean up and treatment of this particular airplane later.

Heavy corrosion at the rear spar attach point.

We see two to four Cessnas in this condition every year. How could this owner have been told his airplane was corrosion free? The answer is both objective and subjective.

The objective answer has three parts. First, the airplane was getting regular treatments with a popular and effective spray product like Corrosion X or ACF 50. Properly applied, these products do a fine job of stopping corrosion in its tracks, but they are typically applied everywhere but those hard-to-access cabin areas. The airframe, wings and fuselage look good with this type of treatment, but these petroleum-based corrosion sprays are damaging to upholstery materials, and since access to the inner cabin structure and skins is so difficult anyway, the cabin doesn't get treated.

Second, the cabin is the most corrosion-prone part of the airplane due to the fact that it is closed up and insulated. It stays warm as the airplane goes through thermal cycling when it's taken to altitude or as the temperature changes when the aircraft is stored. Our airplanes sit in un-insulated, often humid T-hangars or out on the flight line, and add to this the fact that these airframes leak when it rains and the whole mess becomes a flying humidor. When you take the airplane from a surface temperature of 75° to a cruising altitude temperature of 40°,

Head cover, eye protection, charcoal mask, long-sleeved shirt, gloves, scotchbright, lacquer thinner and lots of tenacity - not much fun!

condensation will form on the inner cabin skins. This moisture is absorbed by the hydroscopic insulation, upholstery foam and finish materials. When stored in a hangar or out on the tie down with the doors tightly closed the moisture cannot easily escape.

The third objective reason for this situation lies in the fact that so little of the interior other than carpet is removed during routine inspections. The cabin area, especially the upper cabin, is usually overlooked. In Cessnas, the cabin top is where we find most of the trouble (moisture vapor rises). At you next annual, open up the headliner, remove some insulation and take a look. You might be surprised.

It's my opinion that there are a couple of subjective reasons why most mechanics either don't know or don't want to tell you that these airplanes are corroding in the cabin area. Your mechanic probably hasn't seen the evidence. They don't particularly enjoy working with interior components, especially headliners. Cessna did not exactly make access to the headliner area easy. The stretch vinyl types almost self-destruct when you try to remove the edge material from the sharp retainer strips that secure the headliner along the tops of the doors and rear windows. And the delicate and now quite old plastic headliners are also easily damaged when removed and reinstalled. It's easy to see why mechanics don't want any part of this.

Second, corrosion clean up and treatment is about as much fun as changing the sheets on a bed full of rattlesnakes! So with plenty of other work to be done in other areas of these aging Cessnas, real corrosion issues have been swept under the carpet (or headliner), so to speak.

Well, I'm going to let the cat out of the bag. Before getting into the hands-on account of how we remove and treat corrosion, I will get down off my soap box and put on my best teacher's cap and discuss the chemistry and physics that cause corrosion in the first place. I'm a big believer in understanding the theory behind what we do. We can either be conditioned or we can be educated; I prefer the latter.

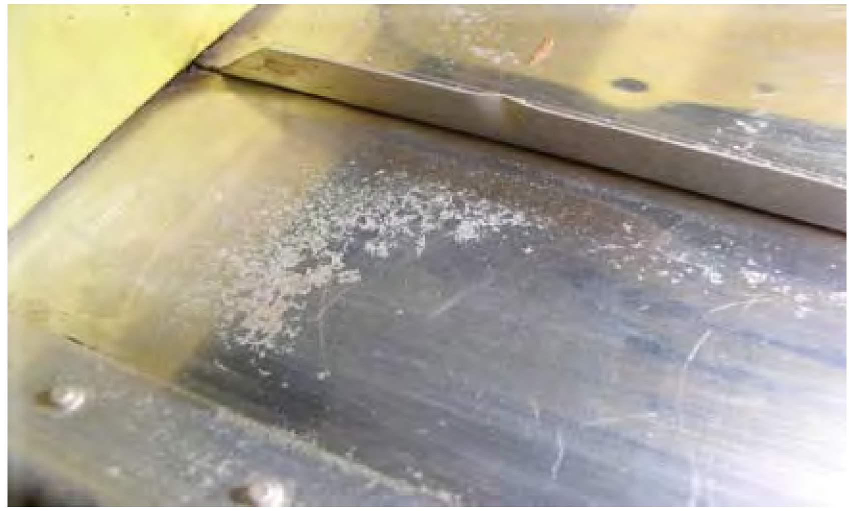
What is corrosion?

To understand corrosion, we must first understand how aluminum alloys are made. In the metal game, alloy refers to the fact that a given metal is made from two or more base metals. Whenever two dissimilar metals are combined to create an alloy that has the desired properties for the engineering task at hand, that alloy has the potential to revert over time to its base metals. During the process of this material returning to its base metals, oxides are formed. A major contributor to the forming of oxides is the fact that all base metals and alloys have different electrical potential.

And that brings us to the first of the two major causes of corrosion: electron flow, or galvanic action, caused by the flow of electrons between the differing metals in the alloy. As the electrons flow through the alloy while the different metals try to revert back to their original states, oxides form that can eventually become corrosion. Exacerbating this situation is the fact that the manufacturing process of aluminum is not perfect. Any given piece of aluminum alloy can have uneven metallurgical content in different areas of the sheet, causing electrons to flow from one part of the sheet to another, and between different sheets that are riveted together in an airplane.

Compounding the problem is the fact that airplanes are an assembly of parts made of many different alloys (steel crankshaft, lead and silver engine bearings, bronze landing gear bushings, hard chromed shock strut components, aluminum airframe structure). All of these different materials combine to make this beautiful object a very complex electron host.

The second major cause for corrosion in airplanes is the addition of an electron flow enhancing electrolyte in the form of moisture. The introduction of moisture and moisture-born contaminants, such as industrial pollutants or salt air, act to increase the flow of electrons on the surface of aluminum alloys as well as between the various different metal components in the airframe structure. We've all heard that airplanes based near the ocean are known to be corrosion buckets. However, you don't have to live ocean side to experience the problem. If your airplane is exposed to salt air during even one visit, salt crystals remain in the airplane. These crystals can begin to cause corrosion when the airplane is brought home to an inland environment where humidity can create condensation, reactivating the salt crystals left in the airplane from its visit to a near-ocean airport.



Very early stage of surface corrosion - a light discoloration on the aluminum skin.

This entire subject of corrosion is so complex that the FAA devotes eight pages in AC 43-13 1B chapter 6, to the subject. This document is available on the internet for those who are interested.

What are the different types of corrosion?

1. Surface corrosion. This is caused by the natural oxidation process of aluminum and its reaction to oxygen and external contaminants, and of course electron flow. It is important to understand that 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 airplane structures. Anyone who has ever had a 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 be black from oxidation that has built in that very short time. Left unpolished, the surface will lose its luster and begin to develop a thin light grey haze which will become a chalky powder on the surface after several months, which then becomes a crusty coating. Left indefinitely it will begin to pit and erode the aluminum.

Surface corrosion is very much accelerated by moisture, such as humidity and/or polluted rainwater. When water mixes with certain contaminants it can become an electrolyte that increases electron flow and corrosion. To make things worse, Cessnas manufactured from the early 1970's through the end

Moderate surface corrosion - a thin powder-like crust with very slight pitting in the metal.

of production in 1986 had lead vinyl skin-stabilizing dampener panels bonded to the inside surfaces of the bare aluminum skins. Even worse, Cessna used hydroscopic glue that soaked up and retained moisture. How perfect – all the bad stuff in one place (dissimilar metal and permanent moisture). Again,

Severe surface corrosion - very crusty with deep pitting; note glue residue on the metal.

the picture is worth a thousand words. The only good news is that when the corrosion between the damper pad and the skin is this bad, the pad is easy to remove. This is a common situation, especially in airplanes that are stored in a humid environment.

Surface corrosion isn't limited to the airframe. Over the years, we have seen several severely corroded seat structures caused by the improper flame proofing of upholstery materials. The flame proofing chemical that is applied to finish materials contains a bromide salt. If it is improperly applied or applied in too great a concentration, this salt, if exposed to high humidity or water, will mix with the moisture and create an electrolytic vapor or water solution that causes severe corrosion in aluminum or steel. The seat frame shown here was so severely corroded by this phenomenon that it had to be replaced.

2. Filliform corrosion. 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 primers and paint were applied. Once trapped by the paint, the corrosion develops and has the appearance of a spidery growth or a lake bed pattern under the painted surface.

3. Fretting corrosion. This is a corrosion resulting from the normal causes of corrosion exacerbated by 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 accelerates the corrosion of the material as the parts rub together, mechanically forcing the corrosive oxides into the metal.

4. Inner granular corrosion. This is a corrosion that is not caused by surface contaminants but is caused primarily by differential metal content of the alloy or a contaminant that became imbedded in the alloy during the manufacturing process. These dissimilar materials cause a very high level of inner electron flow (galvanic action) in the metal, resulting in the formation of internal corrosion and oxidation, and eventually making the metal swell as the pressure from the inner granular corrosion oxides try 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.

Heavy surface corrosion found under a lead vinyl sound damping panel.

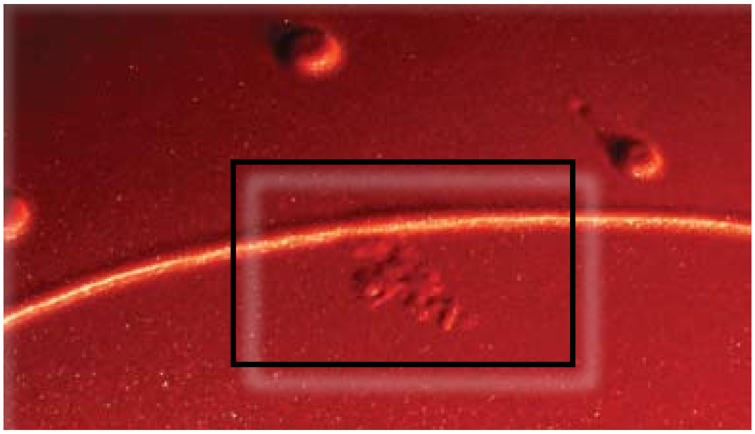
What are the various stages of corrosion and what does each look like?

The first stage of corrosion is a discoloration of the metal, usually noticed when a polished bare metal airplane sits outside and begins to look dull. Or if 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 in the form of a gray powder or crust on the surface of the metal, or under the surface of the paint in the case of filliform 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 non-destructive testing methods, such as ultrasonic tests that can detect an anomaly in the density of an aluminum component.

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

Severe corrosion damage on a seat frame caused by improper flame-proofing of the upholstery material.



Filliform corrosion migrating out from a skin lap joint.

Cardinal seat rail split open by inner granular corrosion (this airplane had come out of an annual one week prior to being delivered to our shop for an interior).

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 electrical system. At the point of contact, at least three different metals come together: the steel metal fastener, the silver-coated 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. Metal oxides cause resistance at the point of contact, resulting in a non-functioning electrical component or 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. We all read with horror the report of a Chalks Albatross that had a wing separation in Florida. When the wreckage was recovered, corrosion was very visible at the point of failure. We see licensed airplanes every day that appear to be well on their way to being in the condition of the Albatross. An accepted rule of thumb is that if the depth of the pitting in a structural component is more than 10% of the thickness of the metal, the component must be replaced, reinforced or repaired. These repairs may need to be approved by the airframe manufacturer or a DER (designated engineering representative). Certain critical components may be even less tolerant than the 10% rule, and you will have to refer to the aircraft maintenance manual for data on this condition. 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.

In subsequent installments we will look into specific corrosion problems common to the Cessna family of piston aircraft, analyzing cause and detailing proper repair as well as prevention. I know this isn't much fun, but it's the foundation upon which a successful renovation is based, to say nothing of long-term ownership. Until next time!