Taming the Corrosion Monster

PART I

By Jim and Reese Leach

Corrosion is the biggest problem for aging aircraft. Like a wild beast, it can be reined in and tamed. We operate an aircraft maintenance shop in South Florida and service hundreds of aircraft a year with varying stages of corrosion. We own a 1956 G35 Bonanza. Probably no one at Beech thought it would still be flying after 55 years. We think it is a real testament to the design and workmanship of Beechcrafters, but our aircraft are aging beyond what the designers envisioned for product life. We must be proactive in our approach to continue enjoying our Beechcraft.

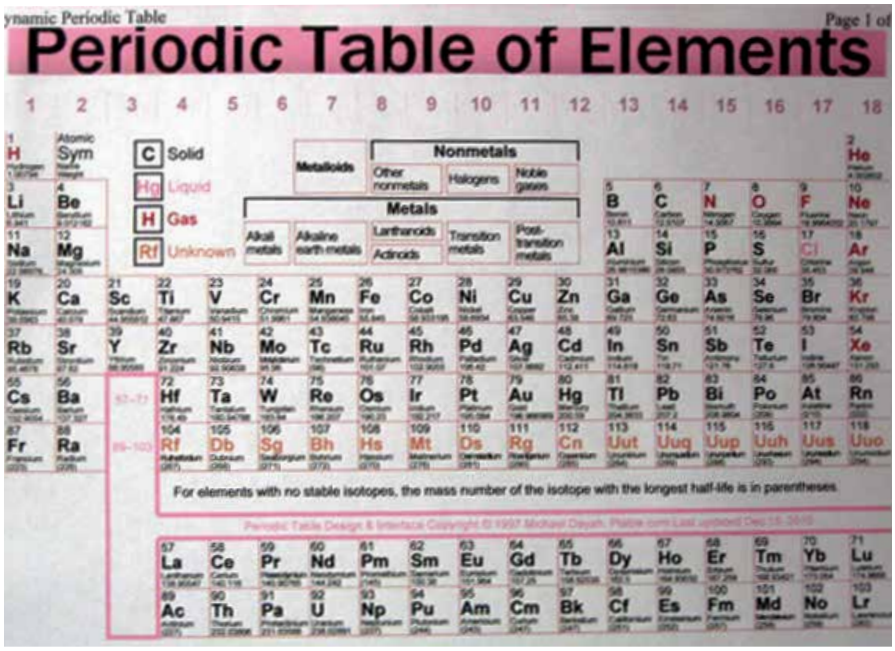

FIGURE 1: Periodic Table of Elements.

Corrosion is a concern because it reduces metal thickness, produces stress risers, and reduces the strength of a component. Corrosion can happen in any environment, it just happens at a faster rate in polluted and/or coastal areas. Most corrosion is preventable if owners take steps to break up the sequence of events leading to corrosion.

Causes of Corrosion

Our study starts at the molecular level. Aircraft are primarily made with aluminum, iron (steel), and magnesium. A quick look at the Periodic Table of Elements (**Figure 1**) shows how these metals have only a few outer electrons. These loosely held electrons are "happy" to combine with other elements – such as oxygen and hydrogen – forming oxides, or corrosion. Both oxygen and hydrogen are abundant in our atmosphere in the forms of gas and water vapor. Other metals that are less susceptible to corrosion are either too heavy or not strong enough to sustain flight loads. Keeping aircraft surfaces painted is the key to halting this type of corrosion.

Another type of corrosion occurs when two or more dissimilar metals make contact. This situation has the potential for a galvanic reaction, or simply, to act like a battery. Electrons from the anodic element (aluminum and magnesium) flow to the more cathodic metal (steel). Add some water (rain or dew) as a potential electrolyte and the battery starts to work. Add some chlorides (as are commonly found in coastal areas or in industrialized areas) and the electrolyte becomes more effective. Add heat and the rate of chemical reaction increases. Put it all together and you have an environment ripe for corrosion to occur. Separating the dissimilar metals will stop this type of corrosion.

Fretting corrosion, as it is sometimes called, occurs when two metal parts rub or vibrate together to produce erosion, pitting, and stress risers. Placing an anti-chafe barrier between the two surfaces reduces or eliminates this form of corrosion.

Corrosion can be controlled. Break the chain of corrosion by separating dissimilar metals or reducing environmental impact and corrosion can be stopped dead in its tracks. Great savings in maintenance can be achieved, it just takes some additional time and planning. Jim served as a Naval Aviator aboard an aircraft carrier. Talk about an ideal environment for corrosion! Yet, the Navy keeps their aircraft relatively corrosion free, because they have a plan and take the time to ensure the plan works. For instance, in Jim's squadron every aircraft was scheduled for three days of corrosion control work each month.

Your plan doesn't have to be this intensive unless your aircraft is tied down near a sea wall in the islands.

The Strategic Anti-Corrosion Plan

The number one recommendation for coastal-based aircraft is get a hangar! A hangar ensures that your aircraft is not subject to dew and rain while it is stored. Most metallurgists describe a severe corrosion environment as one in which a component is exposed to water for 2,500 hours or more each year. The typical coastal airport is exposed to dew starting from about 10 p.m. until the dew evaporates at about 10 a.m. the next morning. That's 12 hours a day. If your aircraft is tied down in such an outside spot year round, your aircraft is being exposed to water for over 4,000 hours a year! This figure doesn't even count rainy days. Hangars are expensive in most coastal areas, but our customers have found they pay for themselves by significantly limiting the expense of corrosion and sun-related aging. The hangar is also the first line of defense in areas with polluted or highly acidic air.

The number two recommendation is to wash and wax your aircraft regularly, at least every quarter if you are based in a coastal area. Local helicopter maintainers wash their aircraft and engines each day. It may not be the glamorous part of preventive maintenance, but it sure gets you "up close and personal" with your aircraft. A lot of other little problems are noticed and corrected before they get larger, less safe, and more expensive. Save the pressure washer for the driveway – too many parts can be damaged. There are many safe and effective solvents for your aircraft without risk of pushing grease out of, or water into, places it shouldn't be.

Now that we've addressed the things that help the entire aircraft, we will look at your aircraft from stem to stern to develop a detailed corrosion control plan. We'll start with the most expensive parts of the aircraft first that get the most reward for our efforts.

FIGURE 2: Salt crystals on propeller blade.

Propellers

All propellers experience loss of paint on the leading edges due to erosion. The exposed metal on the leading edges of the blades can then be attacked by corrosion. **Figure 2** depicts salt crystals that have formed on a propeller blade. This is a typical issue in coastal areas. Keep a towel used for checking oil in a plastic bag in your baggage compartment, and use it to wipe down the propeller blades after each flight. The oil on the towel places a barrier between the aluminum propeller and the surrounding environment.

Attention to rotating hardware is important. Propeller parts experience the highest and most diverse stresses of any component in your aircraft. Bending, tension, and torsional loads are additive in considering stress and strain on parts. Metal fatigue produced by corrosion can lower the component strength and produce a catastrophic failure.

FIGURE 3: Rusted internal parts from a Hartzell propeller.

FIGURE 4: Engine exhaust flange leak indication.

Each brand of propeller has its own corrosion weakness. In McCauley constant speed propellers, the blades are retained in the hub with a steel snap ring placed in a groove machined in the aluminum propeller blade. Let's see… dissimilar metals, a humid environment, chlorides, and heat. Corrosion definitely has a chance here!

The snap rings are relatively inexpensive and easy to change, but corrosion in the propeller blade groove is more difficult and costly to remove. Often the propeller blades must be disassembled from the hub and the groove machined in order to remove the corrosion. McCauley has a limit on how wide this groove can be. If the groove exceeds these limits after corrosion cleanup, the blade must be rejected. You want to avoid this development because propeller blades are very expensive! We recommend spraying these snap rings with a light coat of CorrosionX or other light oil (available in most pilot shops in an aerosol can) after every flight.

Hartzell propellers develop corrosion internally if the propeller has not been serviced with grease regularly. **Figure 3** shows rusted internal bearing races from a Hartzell propeller. Ensure that the shop performing your annual inspections greases the propeller correctly each year. Also, if you notice grease or oil leaking from your propeller, have a knowledgeable person look at it immediately. Resealing the propeller is far less costly and safer than delaying inspection and finding that all the internal parts need to be replaced.

FIGURE 5: Exhaust stud erosion.

FIGURE 6: Wrist pin wear mark on cylinder wall.

FIGURE 7: Searching for oil filter debris.

Engines

The engine exhaust system operates in one of the toughest environments in the aircraft. Extreme heat and expansion and contraction with each start and shutdown make for accelerated corrosion and fatigue. Engine exhaust flange leaks (**Figure 4**) are relatively easy to fix. The flange gasket needs to be replaced to halt the leak. Keep an eye on this area and repair it as soon as possible!

If left in this condition for even 50 hours, the exhaust studs will suffer a combination of erosion and corrosion that causes significant metal loss (**Figure 5**). The exhaust studs can be significantly weakened by the loss of metal. The stud can break off when attempting to replace the gasket. Now instead of just replacing the gasket, the stud must be replaced. In order to install the stud correctly, the cylinder often has to be removed and sent to a machine shop facility for repair. What was once a simple repair, replacing the exhaust gasket, is now a more complex and expensive cylinder repair.

Most factory cylinders have nitrided steel walls. Many replacement cylinders have chrome or nickel plating to enhance corrosion protection. As both Continental and Lycoming have recommended for years, the best corrosion remedy is to run the engine in-flight for a period of at least one hour each week. If the engine suffers long periods of inactivity, cylinder walls can corrode, causing piston ring wear, and wrist pin plug wear (**Figure 6**). The result is debris in your oil filter (**Figure 7**) and cylinder wall scoring.

If your engine is not going to operate for long periods of time, preserve it in accordance with the engine manufacturer's recommendations. Several customers have begun using crankcase dehydrators. These devices draw air through a dehydrating medium using an electric air pump and then force it into the engine, reducing water vapor in the engine crankcase. These dehydrators can be connected to the engine after each flight. This is an excellent approach if you keep your aircraft in a hangar with electrical service.

Other victims of inactivity are valve lifters and cams. Corrosion degradation is accelerated with these parts as they are subjected to high rolling and drawing stresses with each engine revolution. These parts are most conveniently inspected at time of cylinder removal. Whenever a cylinder is removed, take the opportunity to inspect the cam and valve lifters that are exposed. Lycoming and Continental have service instructions for these inspections. Corrosion of lifters and cams leads to spalling failures (**Figure 8**). Correcting these problems can be very expensive. If you are buying a new aircraft that you suspect has had periods of inactivity, consider demanding an inspection of the lifters and cam lobes. It will cost you additional money, but if you find corrosion and spalling you can avoid buying a big, costly problem!

FIGURE 8: Valve lifter spalling.

Fuel components such as throttle bodies, carburetors, fuel valves, and fuel distribution valves can all corrode if exposed to some water in the fuel – especially if the water is allowed to sit in place due to inactivity. We recently worked on an engine that intermittently ran rough. The owner had just purchased the aircraft without performing a pre-buy inspection. The logbooks showed the same hour meter reading for the past three years, but the owner was told the aircraft had flown regularly. The fuel servo and fuel distribution valves were sent to a fuel accessory shop for repair. Extensive corrosion was found in both components.

Turbocharging systems are susceptible to accelerated corrosion due to their high operating temperatures. Waste gates, exhaust pipes, and exhaust pipe clamps are weakened by corrosion and can fail with disastrous results. These components should be inspected regularly and replaced as necessary or as specified by the manufacturer.

Next month Jim and Reese will conclude with their strategy for taming the corrosion monster.

Taming the Corrosion Monster

PART II

By Jim and Reese Leach,
Windward Aviation, Lantana, FL

Corrosion is the biggest aging aircraft problem. Last month, Jim and Reese Leach, owners of an aircraft maintenance shop in south Florida that services hundreds of aircraft a year, began an article on combating this greatest threat to the structural integrity of airplanes. Here's their conclusion. —Editor

Battery Box

Most aircraft have wet cell batteries installed. These batteries can cause acid spills in the battery box if the battery boils over or is over-serviced with water. All batteries (sealed or serviceable) vent acidic gases as well. These acids attack the battery box. It is important to ensure that your battery box is cleaned and checked for proper venting and drain operation at least annually. **Figure 9** shows a corroded battery box. Sometimes it can be repaired, but often the damage is so severe that repair is not practical so it must be replaced with new. If faced with this dilemma, research stainless steel STC'd battery boxes available for your particular aircraft.

FIGURE 9: Corrosion in battery box.

Control Cables

Most control cables are made of multiple strands of steel wire. They are very, very reliable, but they do corrode and strands start to break (**Figure 10**). Cables should be checked at the time of annual inspection. If broken strands are found, they should be replaced immediately. A little Corrosion-X or light penetrating oil goes a long way here. Corrosion is a likely factor in the control cable issues that led to Australian Airworthiness Directives early this year.

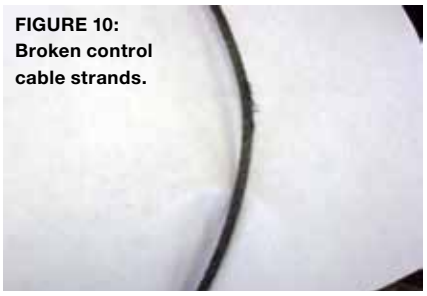

FIGURE 10: Broken control cable strands.

FIGURE 11: Corroded cockpit floor.

Fuselage

Areas of the fuselage near doors or windows are prime areas for corrosion. **Figure 11** shows a corroded floor panel. The aircraft was tied down outside for its entire life. The cabin door developed a leak, which was not fixed for several years. The owner just considered the water intrusion as a nuisance and odor issue. As a result, water entered the cabin and soaked the carpet on the cabin floor. An electrolyte (water) was now in contact with the floor skins and various fasteners in the floor (dissimilar metals). The corrosion damage was so extensive that the owner had to consider the economic feasibility of retiring the aircraft! Keep doors and windows sealed. Keep your aircraft in a hangar if at all possible, or get a cover for road trips to prevent invasion of water.

Heat and ventilation air for aircraft cabins are delivered via ducting often called SCAT tubing. The steel wire in these ducts will corrode over time. When the wire corrodes, it breaks and punctures the ducting walls. Moisture and carbon monoxide can now enter places they were never intended to, such as the cabin or aircraft instruments. If the leaks occur in places not inspected for many years, such as behind interior panels, devastating corrosion can occur. For an aircraft parked outside in a coastal area, you may need to change this style of duct annually.

FIGURE 12: Bird's nest debris being removed from rudder.

Aircraft manufacturers design vents in the bottom of the fuselage in order to let entrapped water and other fluids escape. These drain holes can clog with debris. If your aircraft is not parked on a level surface, some water may be trapped inside. At annual time, it is important to ensure these drains are clear.

ELTs should be checked for leaking battery acid. We have discovered several ELT battery packs that have leaked acid onto the aircraft structure below the ELT. These leaks caused significant corrosion that had to be repaired with fuselage skin patches.

Last but not least is corrosion from rodents, birds, and insects that make a home in your aircraft. Animal urine and feces are quite acidic and will corrode aluminum, magnesium, and steel. It is important to remove floorboards and inspection panels during annual inspections to search for nests and animal remains (**Figure 12**).

Flight Control Surfaces

Almost all Beechcraft have at least some magnesium-skinned surfaces. Magnesium is one the most anodically active metals used in aircraft construction. Corrosion advances quickly in magnesium parts. Inspect frequently for corrosion on such parts, and address any corrosion found immediately.

Ensure that drain holes in control surfaces are open. If plugged, they can trap water that leads to corrosion as well as potential control balance problems. Ever move the ailerons during a pre-flight inspection after a heavy rain and have water drain out?

Wheel Wells

Aircraft with retractable landing gear have their own unique corrosion concerns. Water and dirt get lodged in tough to access places when wet wheels are retracted. Operating from grass landing fields requires more attention to cleaning wheel wells to prevent corrosion from gaining a foothold. Undetected moisture and dirt can cause big, costly problems with electrical components as well as corrosion.

The gear doors of retractable-gear aircraft are often made of two sheets of formed aluminum that are spot welded or riveted together. Water can accumulate between these skins and start a corrosion attack. Over time, it will develop into a major repair or outright replacement of the gear door. These doors usually have a provision for sealing lightening and hinge access holes. Ensure that these seals are secure, and repair as necessary.

FIGURE 13: Heater fuel fitting corroded from within.

Heaters

The muffler heaters of single-engine aircraft must be inspected at least annually. Holes develop in these heaters by a combination of corrosion, bulging, and cracking. Neglecting a heater muffler problem can lead to carbon monoxide poisoning. Each year, the National Transportation Safety Board attributes accidents to carbon monoxide poisoning from leaking heater mufflers.

Twin-engine aircraft use combustion heaters to provide heat to the cabin. Whether used regularly or sporadically, these systems need attention. Water can accumulate in the fuel lines. **Figure 13** shows an aluminum fuel fitting on the bottom of a combustion heater that was completely corroded from within. Various safety features, such as low fuel pressure or combustion chamber leak detectors, must be serviced to keep the heater operating safely and reliably. Make sure your shop inspects and functionally tests your heater at every annual or 100- hour inspection. Each heater manufacturer has instructions for continued airworthiness that specify special testing procedures.

Landing Gear Retract Mechanisms

Landing gear parts are particularly susceptible to chipping and scratches due to the moving and flexing parts. Such paint breaches should be treated when found to avoid costly part

replacement. Exposed rod end bearings and threaded rod features of adjustable landing gear parts need to be checked for corrosion and replaced as necessary. Corroded and/or misadjusted rod ends bearings have been attributed to nose gear collapses for Barons and Bonanzas. Routine greasing of zerk fittings and wear points also contribute to corrosion avoidance.

Electrical Systems

Not many of us have 40-year-old televisions, much less any electrical device that we use outside in the presence of heat, oil, and/or vibration. But many have 40-year-old (or older) airplane wiring. Any electrical connection is susceptible to corrosion, but pay particular attention to electrical grounds. Corrosion in headset jacks and marginal engine and flight control bonding straps can be the source of relatively easy-to-fix radio reception, and engine starting and charging problems.

Wings

Wing attachment bolts and spar recesses can be corrosion havens, too. Keeping bolts lubricated and wing bolt tub drain holes clear are all that's required to save time and big money on Beech wings.

Fuel cells are installed in aluminum cavities. These areas are seldom inspected between fuel cell changes. It is very important to the life of the fuel cell and wing skins to thoroughly clean and properly re-tape the fuel cell cavity. Our shop opens fuel cell access panels annually and sprays Corrosion-X in these areas.

Water can sometimes form in metal tanks, such as "wet wing tips" on Barons and some aftermarket tip tanks – away from drains. This is especially so if the wing is tilted due to unequal strut inflation or parking on uneven pavement. This water can cause corrosion to form inside the tank and corrode it from the inside out.

Sumping the fuel cell drain valves each time you fly does more than ensure that the engine is not ingesting water. Sumping regularly keeps water from prematurely corroding the drain valves, too.

Conclusion

Corrosion is detrimental to flying safety and aircraft value. However, it can be defeated with a combination of frequent, periodic inspections and relatively simple maintenance actions. We urge you to develop a corrosion control plan for your aircraft. Talk to your maintenance provider about corrosion susceptible areas on your particular aircraft. Keep looking for corrosion and defeat it as soon as it's found. Tame the corrosion monster!