Fatigue and corrosion are a powerful one-two punch that could knock out older aircraft. Are you up for the fight?

While at cruise altitude during a scheduled airline flight from Hilo, Hawaii, to Honolulu, on April 28, 1988, an Aloha Airlines Boeing 737 suffered explosive decompression of the cabin roof, peeling away a complete upper cabin section from the floor line up. The pilots skillfully made an emergency landing at nearby Maui. One flight attendant was ejected from the aircraft and her body was never found. Many of the passengers and cabin crew were seriously injured, but miraculously, the only fatality was the flight attendant.

There were many contributing factors to this tragedy: inadequate maintenance procedures, poor inspection techniques, outdated manufacturing methods and lack of management oversight. The spectacular images of the roof-less aircraft, with passengers still in their seats, caused a shockwave of media attention, which in turn caused the aviation industry and the FAA to take action. The subject aircraft was one of the oldest, highest time and cycle count of its type, and this fact would be used as a catalyst for further study and regulatory action against aging aircraft for decades to come.

The Aging Transport Systems Rulemaking Advisory Committee (ATSRAC), formed in 1999 as result of a federal mandate, was tasked with providing public recommendations to the FAA. The FAA then created the Transport Aircraft — Aging Aircraft Program, launched to investigate and develop mitigation strategies based on input from ASTRAC. After years of study, it was determined that increased attention to structural integrity was needed and that, as aircraft aged, they were more susceptible to the effects of corrosion and fatigue. On Feb. 2, 2005, the Aging Aircraft Final Rule was released (www.faa.gov/aircraft/air_cert/design_approvals/transport/Aging_Aircraft/media/AgingAirplaneSafetyFinalRule.pdf). Though primarily aimed at FAR Part 121 operations, the rule crossed several operational types, including Part 129 (common carriers) and Part 135 (air taxi). Very large aircraft operated under Part 91 were affected, but most corporate and general aviation aircraft were not.

Less than a year after the release of the Aging Aircraft Final Rule, on Dec. 19, 2005, a turbine-powered Mallard seaplane en route to Bimini, Bahamas, lost a wing shortly after takeoff from Miami. The aircraft plunged into the Atlantic Ocean off Miami Beach, killing all 20 people aboard. As the wing separated from the aircraft, the tragedy was caught on videotape by a tourist on the beach, and the image was shown repeatedly worldwide.

The NTSB determined that the nearly 60-year-old aircraft had a preexisting crack on the wing structure, which may have been the source of the failure. Though no widespread regulatory action was taken, as with the 737 tragedy of 1988, it serves as a reminder that vigilance and close attention to aircraft structural integrity are essential.

For maintenance managers, especially those who maintain older aircraft, this increased attention to aging aircraft issues should be taken seriously. Will there be rule changes mandating increased inspection intervals, reduced service lives and increased maintenance costs? What actions should you take today to help mitigate possible mandatory inspections? We examined some of the activities associated with aging aircraft and corrosion control to help shed some light on these important safety issues.
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Chemistry of Corrosion

Most aircraft designed before the computer age were over designed to the point that safety was ensured at the cost of weight and performance. But never in their wildest dreams could the ancient designers imagine that their creations would still be flying half a century after initially taking flight. Corrosion creates microscopic bore holes that look like termite tunnels in pine. These pits and holes create stress concentrations that accelerate the effects of fatigue and conspire to create cracks.

Aluminum in its unalloyed form is very resistant to corrosion; unfortunately it is also very weak. By introducing other metals to the mix — zinc, copper and manganese — strength is increased, but it also increases the susceptibility to many forms of corrosion. At the molecular level, impurities at the boundary layers can cause exfoliation and inter-granular attack. Improper heat treating can create stresses within the alloy, which cause cracking.

Common external causes of corrosion include electrolytic effects of electrons passing through the surface, usually due to water, dirt or pollutants. The transfer of electrons accelerates oxidation and transforms the aluminum material to its weakened natural state, a chalky metallic powder. To help resist the effect of oxide attack, most alloys have a thin conversion coating that purposely oxidizes a layer of outer molecules and prevents further oxygen attack from penetrating deeper into the material.

By applying primer and paint to the surface, an additional boundary is added to prevent oxidation. But paint can also hide the effects of internal attack and mask problems. When you have relative motion between two pieces of aluminum, this thin protective layer of oxidation is removed by fretting and is often observed by a darkened soot-like appearance or smoke trails coming from rivets and joints, indicating trouble.

Under the Microscope

To help better understand the effects of aging and corrosion, the FAA's Small Airplane Directorate and William J. Hughes Technical Center sponsored a research project to evaluate typical commuter-class aircraft for the effects of aging. The task of performing the study was handed to the Aging Aircraft Research Laboratory at the National Institute for Aviation Research (NIAR), Wichita State University. The study began in September 2002 and involved destructive and nondestructive inspections on two Cessna 402s, a Piper Chieftain and, later, a Beech 1900D.

The researchers at NIAR came up with a list of recommendations, which include more in-depth supplemental inspections based on the operational and maintenance history of the aircraft. "Supplemental inspections should include more than just visual techniques and include common NDI techniques [penetrant, magnetic particle, eddy current] as well, targeting hot spots such as major structural attachments, flight control attachment and areas with a history of fleet-wide maintenance issues," said Melinda Laubach, program manager of the Aging Aircraft Research Lab at NIAR.
It is very likely that more aircraft manufacturers will develop similar programs for older aircraft following the guidance and research set forth by the Aging Aircraft Program. Credit: Duncan Aviation

In addition to basing supplemental inspections on service history, common areas that are more prone to corrosion should be addressed frequently. Antenna mounting areas are particularly susceptible to corrosive attack as moisture that penetrates the sealant will remain trapped between the antenna and fuselage. Pilots and maintainers should be vigilant when surface corrosion is first detected, often under bubbling paint or exposed skin, and promptly repair the condition before it spreads.

Maintainers should pay close attention to the FAA Service Difficulty Report Database (http://'av-info.faa.gov/sdr) to keep current on areas of trouble found by others, as well as provide an opportunity to share what they find. "I strongly recommend increased usage of the Service Difficulty Report Database. If all issues were appropriately reported in this database, owners/operators would have a much better idea of the specific issues that plague their model of aircraft," Laubach said. "I believe this type of fleet-wide maintenance history is key to directing appropriate inspections to specific locations at critical times in the aircraft's life."

Corrosion Prevention and Control Program

During the years leading up to the release of the Aging Aircraft Final Rule, there was a proposal to require mandatory Corrosion Protection and Control Program (CPCP) plans as part of the continuous airworthiness process. The measure was stricken from the rule as it was believed to be covered as part of the normal airworthiness process. Many large transport aircraft have similar programs incorporated by Airworthiness Directives and approved airline inspection plans.

The concept is beginning to gain traction among business jet OEMs. The Falcon 50 has a mandatory CPCP inspection program identified by EASA Airworthiness Directive F-2004-162, which directs the operator to comply with a series of mandatory inspections as aircraft approach 30 years in service. It is very likely that more aircraft manufacturers will develop similar programs for older aircraft following the guidance and research set forth by the Aging Aircraft Program.

To better prepare for future mandatory inspections, the best course of action is to ensure that you are not only following the manufacturer's recommendations, but are adjusting them to suit your specific operating environment to protect against corrosion today. "Often the manufacturer's lubrication and inspection intervals are not adequate for extreme environments," said Patrick Voeller, general manager at Long Beach, Calif.-based Airflite Aircraft Maintenance, whose aircraft often fly in warm, humid and salt-laden environments. "We've performed gear lubrication and inspections at half the allowable intervals to keep up with corroding hardware," he added.

When OEMs offer corrosion-resistant component upgrades, or kits to more easily inspect and treat corrosion, it is highly likely they will pay off over time. During heavy maintenance activities, be sure to document any findings and take action to address minor problems while they are still small. If it appears that recommended inspection intervals are not keeping your aircraft problem-free, consider reducing the interval.

When the OEM provides guidance for corrosion prevention activities, be sure to implement them when possible. Avoid aftermarket cleaners and solutions that are not authorized for your aircraft. Dry washing aircraft reduces the chance that water, cleaners and pollutants can seep into voids in the aircraft skin. Pressure washers should never be used on aircraft as they can destroy sealants and force open skin seams.

Even though aircraft appearance is very important to operators, multiple repainting can increase the probability of corrosion-related problems. "Chemical and mechanical stripping procedures used in the past can damage the skin and create areas where corrosion can take hold," said Ron Grose, Falcon technical specialist with Duncan Aviation's Lincoln, Neb., service facility. "When choosing a facility to repaint your aircraft, make sure they have a good reputation for not only the finish but for following the manufacturer's recommendations for surface preparation and the stripping process as well," he added.

When your aircraft is in for major maintenance, pay close attention to problem areas where corrosion can gain an early start.
foothold. "Typical problem areas are near the lavatory dump chute, wheel wells, fuel sump drains, lower fuselage areas and APU exhaust. Any area where water can collect inside a compartment should be looked at closely," Grose added.

When your aircraft is in for major maintenance, pay close attention to problem areas where corrosion can gain an early foothold. Pictured is a Falcon wing demate being performed at Duncan Aviation. Credit: Duncan Aviation

New aircraft are designed with damage tolerance and ease of inspection in mind. Their maintenance programs are created for the long term using the latest MSG-3 (Maintenance Steering Group 3) analysis and philosophy. However, most of the existing business aircraft fleet comprises aircraft that are over 20 years old, and with the current focus on aging aircraft issues, it is almost a sure thing that there will be more mandatory inspections and emphasis on detecting age-related problems. Prior modifications (STCs, Field Approvals, etc.) and repairs to the aircraft primary structure may have to be evaluated for damage tolerance and CPCP analysis.

As a maintenance manager, you need to keep up to speed on the current issues affecting your aircraft, by attending operator committee meetings and closely monitoring the Service Difficulty Report Database for problem areas. If you wait for the FAA to take action on your behalf, you are certain to not like what they recommend. Take action today to make sure that your aircraft, passengers and crew stay safe, and that the effects of age do not send your older aircraft down for the count.

Don't Forget

The 2008 NBAA Maintenance Management Conference (MMC) will be held April 15-17 in Daytona Beach, Fla.

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