Meridian PT6A-42A Compressor Inlet Corrosion & Compressor/Compressor Turbine Washes

9/8/08

From late 2007 to date Piper Aircraft, Inc. ("Piper") has received a number of questions from customers regarding corrosion of the PT6A-42A engine compressor inlet case used in the Meridian aircraft. In an effort to answer these questions, Piper has written this Position Paper to directly address this issue.

When originally proposed for the Meridian by P&WC, the magnesium inlet case used in the PT6-42A engine had a lengthy and reliable 18 year history with millions of flight hours – a solid and reliable history that continues to this day. It has been used – and continues to be used industry-wide on other aircraft powered by PT6A engine models (including the King Air, TBM 700/850s and PC12s) … and for good reason: The magnesium inlet case is lighter, incorporates an oil level sight glass and when maintained in accordance with P&WC recommendations, exhibits no indications of significant corrosion susceptibility, as demonstrated by its many years and millions of hours in service.

Magnesium is the lightest of all structural metals, weighing 35 percent less than aluminum and 78 percent less than steel. The lightweight characteristics and wide availability make magnesium alloys suitable for mass production of components such as housings for helicopter transmissions, compressors, and engines, as well as forgings for critical gearbox components. Magnesium alloy castings are widely used in the aerospace industry due to their superior weight characteristics, strength, and ability to operate at extreme temperatures.

Magnesium Alloy Corrosion

Corrosion is the deterioration of a material in a reaction with the environment. All metals will corrode over time; however, the rate and severity of corrosion varies with the particular metal and the specific environment that the metal is exposed to. Corrosion reactions are electrochemical in nature. One type of corrosion occurs by direct chemical attack on a susceptible metal. Other corrosion reactions rely on the flow of electrons from one area of the metal to another. This often happens over a very, very small distance. These areas are called cells (chemical battery). There are various types of cells and terms to describe them based on the specifics of the reaction, but they all involve the same components. For corrosion to occur, all of the following must be present: (1) two separate areas of the metal surface acting as electrodes (an anode and a cathode); (2) a path for the electrons to flow (an electrolyte); and (3) the metal itself to complete the electrical circuit. This creates the chemical reaction that is corrosion. The metal is attacked and is consumed. The key to managing corrosion is to prevent it from happening. By removing or controlling those elements that create the chemical reaction, corrosion can be managed.

Electrolytes are typically those from the environment. One of the reasons that metals exposed to a "salt laden environment" corrode more quickly is that it creates an excellent electrolyte. It contains chlorides, sulfides, and other elements and compounds that chemically react with the metal. These materials hold moisture on the surface where

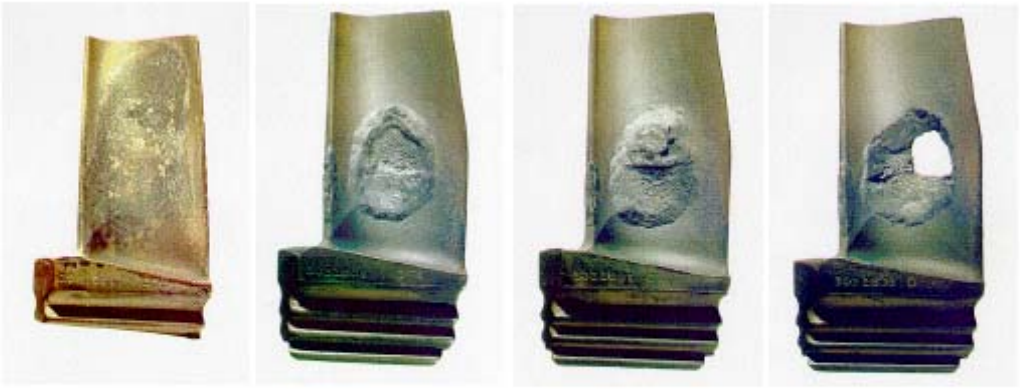
they can promote corrosion and pitting unless the metal, as in the case of the engine compressor inlet, is protected by properly applied coatings. Severe corrosion may occur in neutral solutions of salts of heavy metals, such as copper, iron and nickel. Such corrosion occurs when the heavy metal, the heavy metal basic salts, or both, plate out to form active cathodes on the anodic magnesium surface. Chloride solutions are especially corrosive because chlorides, even in small amounts, usually break down the protective film on magnesium alloys. Additionally, magnesium components such as the compressor inlet case and the reduction gear box housing are susceptible to corrosion should the protective epoxy paint become chipped, scratched or eroded.

Corrosion of magnesium alloys increases with relative humidity. At around 10% humidity magnesium alloys do not exhibit evidence of surface corrosion after 18 months. At 30% humidity, only minor corrosion can occur. At 80% or higher humidity the surface may exhibit considerable corrosion. In marine atmospheres heavily loaded with salt spray, magnesium alloys require protection and on-going maintenance for prolonged serviceability.

FAA AC 43-13-1B. 6-148 General states the following: “Magnesium and magnesium alloys are the most chemically active of the metals used in aircraft construction and are the most difficult to protect. However, corrosion on magnesium surfaces is probably the easiest to detect in its early stages. Since magnesium corrosion products occupy several times the volume of the original magnesium metal destroyed, initial signs show a lifting of the paint films and white spots on the magnesium surface. These rapidly develop into snow-like mounds or even white whiskers. The prompt and complete correction of the coating failure is imperative if serious structural damage is to be avoided.”

Sulphidation

Sulphidation is distinctly different from the corrosion being seen on the magnesium alloy compressor inlet case. The important point to remember is that sulphidation is a hot-corrosion phenomenon, and therefore turbine blades are most susceptible to it. Sulphidation occurs at engine operating temperatures with sodium and sulphur present. Most aviation turbine fuels contain sulphur in sufficient amounts for sulphidation. Common sources of sodium are seawater, atmospheric pollutants and volcanic discharges. Initially sulphidation attacks the oxide protective coating of the turbine blades and as the oxidation accelerates blister scale begins to form. Should sulphidation be allowed to progress the turbine blades will have to be replaced.



Stage 1 Mild

Stage 2 Failure of Protective Oxide Layer

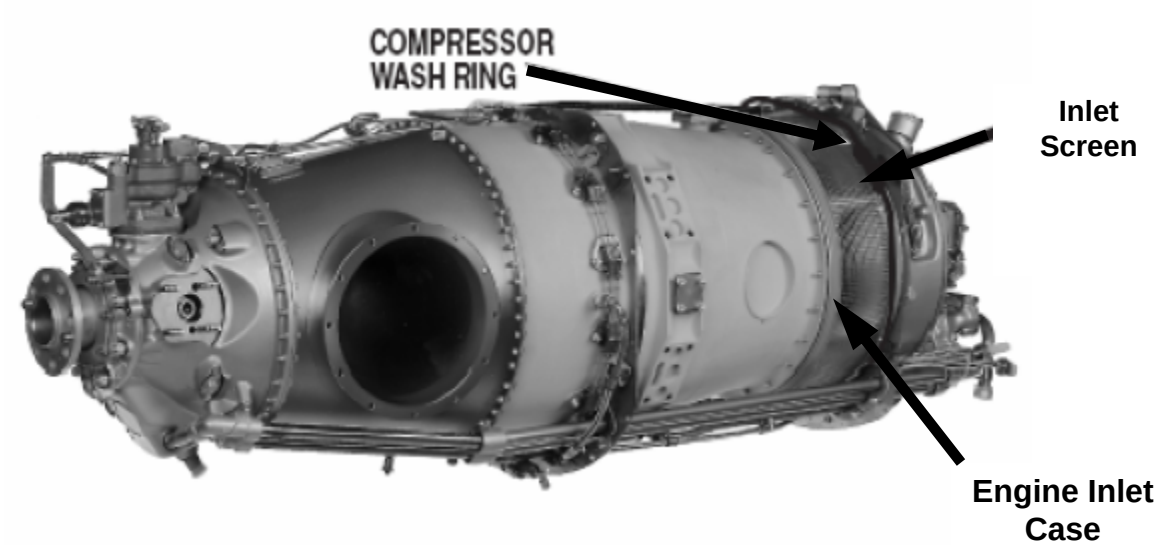
Stage 3 Severe

Stage 4 Catastrophic attack

Meridian PT6A-42A Compressor Inlet Case Corrosion

There have been documented cases of inlet corrosion on both the magnesium and aluminum cases when the engine wash schedule has not been maintained. Reference pictures below:

PT6A Engine



Examples of Corrosion on the Inlet Case




Of the engines where inlet case corrosion has been discovered, the vast majority have either operated or continued to operate in coastal areas. In one of the cases recently cited in print, the engine in question – powering a 2001 Meridian based in Southern Florida – was not properly maintained. In reviewing the aircraft records, Piper found that there were only two desalination washes performed on the engine in its first seven years and approximately 600 hours of operation. That works out to about one desalination wash every three and a half years, or every 42 months – a far cry from weekly washes recommended by P&WC's Engine Maintenance Manual. Additionally, a review of a number of other customers' logbooks found that none of those examined engines showed any type of scheduled washes either.

To reduce the possibility of corrosion, P&WC has defined processes to perform both internal and external engine washes. These washes, which have been in place for more than 40 years irrespective of inlet case material, are defined in the applicable PT6A Maintenance Manuals, Chapter 71-00-00 Powerplant Cleaning, along with recommended schedules as to when to perform these washes based on operational environments.

Chapter 5-20-00, Scheduled Maintenance, of the Piper Meridian Maintenance Manual clearly states that "failure to consult applicable vendor publication(s), when servicing or inspecting vendor equipment installed in Piper aircraft may render the aircraft unairworthy". Also contained in the Event Inspection Worksheet under the "Engine Detailed" section is the statement "Refer to Pratt & Whitney Maintenance Manual P/N 3021442 as required for detailed procedures". References to engine cleaning are contained in a caution note just above item number 8 – "clean exterior of engine" that

states “Obtain all engine cleaning procedures and cleaning precautions from the appropriate section of the Pratt & Whitney Canada Maintenance Manual P/N 3021442.

In addition to performing engine washes, P&WC has approved several corrosion inhibiting products that can be manually applied to the inlet case to deter corrosion. These products, such as LPS Procyon, can be obtained and applied locally, and will be added to an upcoming Temporary Revision to the P&WC Engine Maintenance Manual. To be effective, these coatings must be re-applied on a consistent basis. Because the installation of the engine in the Meridian limits the accessibility of certain areas of the inlet case, applying these coatings will require removal of the inlet screen to gain access to the entire inlet case.

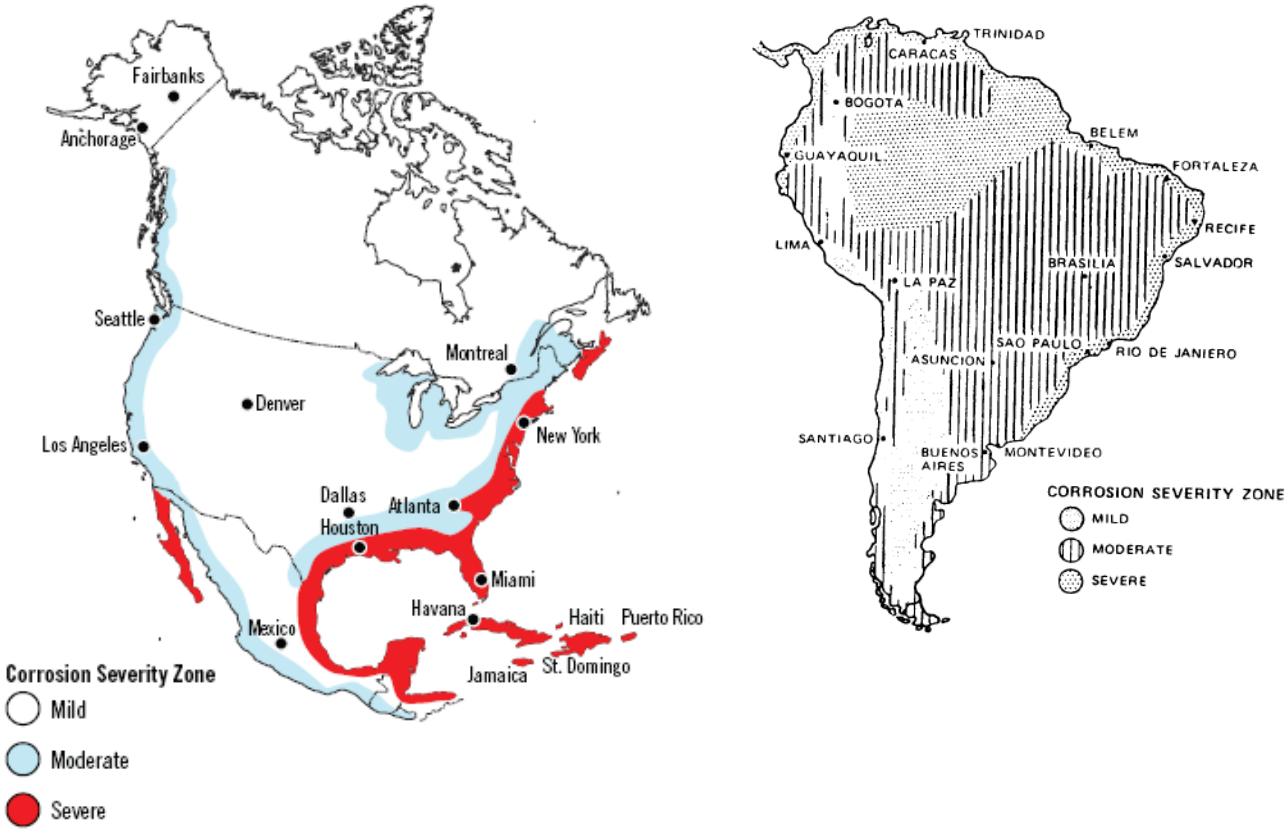
Application of LPS Procyon

Compressor/Compressor Turbine Washes (Desalination)

Compressor desalination washes are required to prevent corrosion and sulphidation on the engines internal components. The primary reason to perform these washes is to remove salt and atmospheric contaminants from the compressor and compressor turbine blades. No one can argue the fact that these washes are beneficial, however, the fact that P&WC strongly recommends that desalination washes, both compressor and compressor turbine, be performed at the end of each day the aircraft is operated in a “continuously salt laden environment” has stirred some conversation. Most operators feel that this recommendation is unrealistic, inconvenient, time consuming and costly. If these washes are not performed corrosion, pitting and sulphidation will occur.

For engines that operate in occasionally salt laden environments P&WC recommends desalination washes on a weekly basis to begin with and then leaves it to the operator to determine a schedule that best meets that operator’s environment. It is P&WC’s position that operators flying in coastal areas should at a minimum perform the recommended washes on a weekly basis.

On February 8, 2008 P&WC revised and released Service Information Letter # PT6A-144 R1. This SIL references FAA advisory circular AC43-4A which provides a comprehensive perspective of the regions in the world that are considered to be aggressive operating environments including regional maps as shown below.



Cost

To address the cost to perform a desalination wash, a recent time study was performed at Piper with the following results:

Remove top & bottom cowling – 5 minutes
Remove exhaust drain and connect wash cart – 4 minutes
Perform compressor wash – 3 minutes
Disconnect wash cart and remove ignitor – 5 minutes
Install adapter, connect wash cart and perform CT wash – 3 minutes
Remove wash cart and adapter, reinstall ignitor, exhaust drain and safety both – 5 minutes
Engine drying run – 5 minutes
Reinstall top & bottom cowling – 5 minutes
Total time start to finish – 35 minutes X 2 people = 70 minutes

Cost may vary depending on the service center and work performed. It is noteworthy to mention that some Dealers have not experienced inlet corrosion so they do not perform desalination washes but instead perform power recovery washes using approved chemical additives to remove more stubborn deposits which cannot be removed during normal desalination washes.

Warranty

P&WC's Warranty Policy, for all products including turboprop, turboshaft and turbofan engines, clearly states that FOD, corrosion, sulphidation, erosion or any other damage caused by operating environments are considered factors beyond P&WC's control and are not covered under the P&WC Warranty Policy.

There are too many variables leading to corrosion, most notably the varying environmental conditions in which an aircraft is operated as well as the owner's adherence to recommended maintenance procedures. The fact that there are no reported events of corrosion where the P&WC's Engine Maintenance Manual requirements where followed correctly is evidence suggesting that these requirements are sufficient to prevent corrosion. However, it's important to know that in instances where corrosion does occur and the owner has documented proof that proper maintenance procedures have been followed, Piper is committed to examining each case to determine whether it's appropriate to cover repair charges.

Continuous Improvement

In the spirit of continuous improvement, both Piper and P&WC are studying ways to further inhibit the effects of corrosion, including improved coatings for metal parts and configuration modifications that could slow down oxidation. Furthermore, Piper and P&WC have endeavored proactively to educate and train customers, distribution and service center operations to ensure that the corrosion issue is understood, prevented and properly remediated if it occurs.

Pratt & Whitney Canada

Most recently, P&WC provided Piper with the following statement on this issue:

"The magnesium compressor inlet case is installed on many PT6A engine models utilized on various aircraft which include the Piper Meridian, EADS Socata TBM700 / 850, Pilatus PC-12, Piaggio Avanti and many Hawker Beechcraft King Air models. Corrosion due to operation in a salt laden environment can occur on both the magnesium and aluminum compressor inlet case if the maintenance recommendations outlined by P&WC in the engine maintenance manual are not followed. Those recommendations consist of a daily compressor and compressor turbine desalination wash when operating in a continuously salt laden environment, or weekly washes when operating occasionally in a salt laden environment. P&WC is sensitive to the maintenance burden that a daily wash places on a typical corporate operator, and therefore recommends weekly wash at a minimum combined with the periodic application of an approved corrosion inhibitor to the compressor inlet case. Further reducing the maintenance burden on the Piper Meridian specifically are the compressor wash ring and P3 air filter with a drain valve which come preinstalled on all engines. It is important to note that any documented reports of compressor inlet case corrosion on the aforementioned aircraft models were the result of an inadequate wash schedule for the operating environment. Should an operator discover corrosion on the compressor inlet case, P&WC is available to review the extent of the corrosion and provide specific

maintenance recommendations to minimize repair costs and ensure a prompt return to service."