Can inlet corrosion be stopped simply by washing?

PIT Stop

by Abram Finkelstein

Imagine you are a relatively new owner of a Piper Meridian, enjoying flying in the flight levels to distant destinations at good speeds with reasonable fuel flow. You take your airplane in for routine maintenance; perhaps the annual inspection.

Shortly thereafter, you receive a somber phone call in which your mechanic delivers the bad news: "We found some corrosion on the air inlet of the engine." Being a relatively astute aircraft owner, you know that the words "corrosion" and "airplane" do not mix well. You ask what that means and the mechanic tells you that it means that the engine will have to be removed and sent to a Pratt & Whitney facility for repair work.

There is no option, as the engine is considered no longer airworthy. No one can tell you how much the repair will cost until the engine has been evaluated more thoroughly. When all is said and done, you have a hefty bill for repairs, the airplane has been down for about eight weeks and you are not quite sure what happened or how to prevent it from happening again in the future.

That scenario, or one substantially similar, has been occurring in increasing frequency for Piper Meridian owners. The story above is my story, however, it is not substantially different from the story of many of the owners that have experienced the same issue.

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In simple terms, the problem is corrosion forming on the compressor air inlet for the PT6-42A engine of the Meridian, often under the seal at the six o'clock position. The problem has been found on aircraft of various ages, from numerous regions and with a variety of engine hours and cycles. Although neither Piper nor Pratt & Whitney Canada (PWC) have provided any statistical information on this issue, there are reports that during the past year the problem has affected more than 40 of the approximately 300 Meridians that have been manufactured. Indeed, several observers believe that this is a problem that will affect most, if not all, of the Meridian fleet in time.

According to Kevin Riecker at Sun Aviation, one of the leading maintenance facilities for the Piper Meridian and a designated Piper Service Center, perhaps three-quarters of the Meridians that have come through his shop in the past six months have had some amount of inlet corrosion. Of those, the majority of the airplanes are from Florida, but they also come from the Midwest, New England, California and Texas.

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Although corrosion is not a stranger to other applications of the PT6, or any other turbine engine for that matter, the corrosion is usually related to older aircraft and it tends to be found on the compressor and CT blades. This situation is different, in that the primary engine component corroding on the Meridian is the engine compressor air inlet case. A magnesium air inlet case is not unique to the Meridian, being found in aircraft such as the TBM 700/850, but other PT6-powered airplanes use inlet case assemblies made of aluminum.

It is important to note that there is enough of a history of corrosion problems with the application of magnesium air inlets on PT6-41 and -42 engines that Pratt & Whitney Canada issued Service Bulletin 3417R1, which outlines "a customer requirement to replace the compressor inlet case assembly made from magnesium with a similar one made from aluminum alloy with better corrosion resistance." It notes that the problem is that "in a severe marine environment, a high degree of maintenance is required to prevent corrosion of the compressor inlet case assembly."

The solution that the SB suggests is to "replace the compressor inlet case assembly with a similar one made from aluminum alloy." However, that fix would also increase the engine weight by 6.61 pounds and would move the center of gravity .26 inches.

Another notable difference between the Meridian and other aircraft is that most other aircraft that use the PT6-42 have an inertial separator door, while the Meridian was designed without it, and some have speculated that this could be leading to the corrosion problem since moisture could be entering the inlet area and not evaporating properly. However, according to Kevin Mead, who specializes in the maintenance of Mirages, Meridians and Jetprops, the Meridian doesn't need the inertial separator door. The air inlet design on the Meridian accomplishes the same function, which is primarily to ensure that deflected ice does not enter the engine.

Engine Corrosion

The corrosion involved in the inlet is sulphidation, rather than the galvanic corrosion generally found on the airframe. Galvanic corrosion is an electro-chemical process that eats away any metal structure. It exists at normal temperatures. Sulphidation is a reaction of a metal or alloy with some form of sulfur to produce a sulfur compound that forms on or under the surface of the metal. This occurs in high-temperature environments and typically has two types: Type I sulphidation occurs between about 1,500°F to 1,750°F, and Type II sulphidation occurs in the 1,300°F to 1,500°F range.

Sulfur oxides created during combustion and airborne salts react with the oxide layer on the blades in the high temperature environment of the turbine to attack the base metal of the blades. This reaction forms sodium sulfates that expose the blade's protective

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Top, corrosion on the inlet case is found in two spots at the 1 o'clock position. One is next to the studs on the interior and not visible. The 1 o'clock position in this photo is the 6 o'clock position when the engine is installed. Center, a closer view of the two spots. Bottom, corrosion found under the silicone inlet screen.

oxide layer to decay. Water is also produced as a by-product of hydrocarbon fuel combustion, and this water can combine with the sodium sulfur compounds to produce sulfuric acid.

PWC has published several manuals on preventative maintenance, including Engine, Turboprop – Inspection, which was released in 2004. In it, PWC notes that sulphidation typically affects the compressor turbine blades, but that sulphidation of power turbine blades and of non-rotating parts such as shroud segments is not uncommon.

Sun Aviation's Riecker noted that, although the corrosion can clearly be accelerated by salt, moisture could also play a role in the corrosion that is affecting the Meridian. He and several Meridian owners have noted that the majority of airplanes that have corrosion in the air inlet have it at the six-o'-clock position. That could suggest that moisture is being trapped between the seal and the magnesium air inlet, which might cause corrosion.

When dealing with corrosion in the compressor or turbine blades, there are acceptable levels of corrosion with which the aircraft can still operate, provided that a boroscope inspection program is started. When it comes to the engine air inlet, however, PWC takes the position that all corrosion must be addressed. Once corrosion of the component is detected, the aircraft is no longer airworthy.

There are several levels of corrosion and each is addressed in a different way.

For very light corrosion, a field repair can be conducted. Initially, field repairs were accomplished without removing the engine, however that practice has ended and currently, the engine must be removed so that the area can be better inspected and to provide enhanced access to the engine air inlet. The repair itself involves sanding down the sulphidated area, treating with a chemical to neutralize the corrosion, treating with solution and painting the affected area.

If the corrosion exceeds the amount permitted in the maintenance manual for field repair, the engine must be shipped to an overhaul facility. At the facility, the inlet is removed from the engine. All paint is stripped off of the inlet and a thorough inspection is conducted. Any sulphidation that is detected is ground down. The inlet is recoated and the coating is baked on.

On a per engine basis, PWC will issue an engineering letter allowing for field repairs even if the amount of corrosion exceeds the maintenance manual limits.

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In a worst-case of engine inlet corrosion, the entire inlet would have to be replaced.

Avoiding Corrosion

PWC stipulates regular engine cleaning as the primary way of preventing corrosion of the PT6-42 engine and its components. Indeed, there is a virtual library of documentation surrounding the various types of washes, as well as the specific procedures for conducting the washes.

PWC Service Information Letter PT6A-144 R1, which was revised in February, addresses the impact of the environment on engine's maintenance requirements. This service letter actually clarifies and expounds upon some of the earlier information by noting that common sources of sodium are seawater, atmospheric pollutants and volcanic discharges. It also notes that the "magnesium components such as

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the compressor inlet case (aluminum on some models) and the reduction gearbox housing are also susceptible to corrosion should the epoxy paint become chipped, scratched or eroded."

Specific to the Meridian, Piper issued a Service Letter in March reiterating and "reinforcing the importance and effectiveness of compressor and turbine washes" in "reducing the onset of sulphidation attacks on the turbine blades and prevent salt deposits from damaging the compressor section."

The Service Letter also attaches PT6A-1441 R1 and notes that corrosion and sulphidation damage are not covered by the PWC Warranty Policy.

In the 2004 release, PWC recommends as a preventive measure "desalination wash using plain water with antifreeze, if required," to minimize attacks. It further notes that "wash frequency depends on the amount of contamination," that "washing weekly is probably the minimum acceptable" and that "maritime areas may require washing daily or before each flight."

In the maintenance manual, PWC also includes a table with the recommended wash schedule, which is dependent upon the operating environment of the airplane. In a continuously salt-laden environment, PWC recommends daily desalination washes of the compressor and CT blades. In an occasionally salt-laden environment, PWC recommends weekly desalination washes of the compressor or CT blades.

PWC has also recommended that "regular boroscope inspections of the compressor inlet case and turbine blades will help to establish whether the wash schedule you have in place is sufficient to prevent corrosion." It also elaborates on the timing of the compressor wash by noting that it "provides best results if performed after the last flight of the day before salt deposits have a chance to do any lasting damage. Leaving the engine to sit overnight will reduce the effectiveness of a wash performed at a later time." It is also recommended to perform a compressor turbine wash immediately following the compressor wash, as the compressor wash will transfer salt deposits into the turbine.

Aside from compressor washes, there are several inhibitors that can be applied to engine components and which may help the metal components within the engine and casing resist corrosion. PWC has authorized some corrosion preventatives, such as Corrosion X and Procylon, to be applied to the top of the air inlets, which is designed to keep moisture and salt off of the painted parts. Because the application of the preventative is relatively new, there is no empirical evidence upon which to rely to determine how frequently to apply the preventative or how effective it will be at avoiding sulphidation.

In addition to the preventative measures that are identified by PWC in the various publications, there have been several other suggestions made by owners, operators and maintenance personnel that may help to avoid sulphidation. Some operators and maintenance personnel have suggested that Meridian owners should avoid flying through weather, as the ingestion of water into the engine could be impacting the incidence of corrosion. In addition, several owners have suggested that keeping the aircraft in a hangar and using engine inlet and exhaust covers will reduce the amount of salt air exposure when the aircraft is parked. That could help to insulate the engine from exposure to the elements and may help to resist corrosion.

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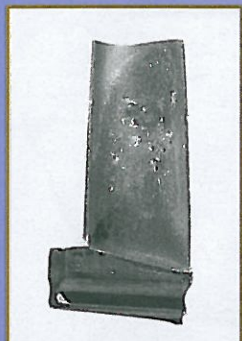
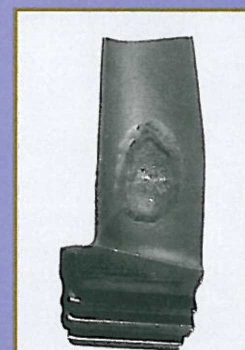
Types of Sulphidation

PWC identifies four stages of in-service sulphidation:


Stage 1

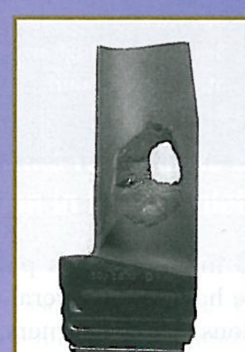
Stage 1 – Light Sulphidation (Initial Coating Deterioration): Slight roughening of the surface and localized breakdown of the protective surface layer. Substrate is not yet affected.


Stage 2

Stage 2 – Failure of the protective layer (Initial Substrate Corrosion): Roughness of surface is more marked as protective layer breakdown exposes the substrate to attack. Mechanical integrity is not yet affected.


Stage 3

Stage 3 – Severe sulphidation: Base material is attacked to significant depth, as evidenced by obvious buildup scale and some blistering. Progression to Stage 4 would accelerate. Integrity is now affected and some parts are no longer serviceable.


Stage 4

Stage 4 – Catastrophic attack: Deep penetration of attack with large blisters of scale. Loss of structural material will lead to eventual component failure.

PWC notes that attack at the level of stages 3 and 4 will normally be limited to engines that are directly exposed to salt water, although it does not identify what qualifies as "directly exposed to salt water."

A Widespread Problem?

Whether the inlet corrosion is an Achilles heel of the Meridian in particular remains something of a mystery. Pratt & Whitney Canada declined to respond to repeated inquiries about the extent of the problem. Piper would say only that it encouraged owners to follow the recommendations in the engine manufacturer's service and maintenance documentation.

We went to MORE Co., which owns an STC that provides enhanced instructions for maintenance of the PT6A-42A and which, if followed, can increase the overhaul interval for the engine. Currently, MORE has experience with more than 1,542 engines, 392 of which are PT6A-41 and PT6A-42 series engines.

Ralph Hawkins, chief engineer for MORE, said he was not familiar with air inlet corrosion except on aircraft that operate on water and that, as a general rule, the PT6A engines do not usually experience the kind of compressor inlet case corrosion that the Meridian fleet is experiencing. Furthermore, PT6As don't typically experience such problems as early in the engine life as is being reported.

Obviously, being in a marine environment will accelerate corrosion problems and requires stepped up vigilance. Any flight that occurs near or over salt water when flying less than approximately 6,000 feet can render the aircraft in a severe or adverse corrosion environment. In addition, however, other environments also render aircraft susceptible to corrosion, such as polluted air and volcanic ash and dust.

All of those factors will require special care, which would include periodic compressor washes and clean water rinses, as well as inspection intervals. Hawkins says an owner who properly performs the washes after each flight, puts the covers on the engine and the plugs on the inlet should not have to

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perform another wash until after the next usage of the airplane or the until the next scheduled wash, whichever is later.

While the cleaning procedures outlined by PWC and Hawkins may be reasonable for commercial operators, many owner/operators contend they are impractical for those who use their aircraft for personal or business transportation. To follow the PWC recommendations, an individual who lives in a coastal or polluted area would still need to perform a compressor desalination and turbine wash every day regardless of the amount of flying that they do.

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Compressor Washes

PWC identifies the procedure for performing a compressor desalination wash in the maintenance manual, which was last revised in 2006. It extensively covers various forms and conditions of engine washing, all of which are relevant to the goal of preventing corrosion in the engine or its components.

The forms of internal washing are identified as a compressor wash, performance recovery wash and compressor turbine wash. In addition, PWC identifies an external engine wash as an effective way of identifying the origin of external oil leaks and of removing contamination by salt or corrosive chemicals.

The equipment required for all of the washes is essentially the same: A wash cart or wash rig, spray wash rings and wand, compressed air or nitrogen, demineralized water, drinking quality water, one pressure gauge, two air supply valves and two fluid shut-off valves, tubing interconnect components, and two flow control valves.

The compressor desalination wash is performed by injecting cleaning fluid into the engine intake using either an installed compressor ring or a hand held wash wand and is used to remove salt deposits, although light dirt deposits may also be removed.

The compressor turbine wash is performed by injecting cleaning fluid into the engine through a wash tube installed into the gas generator igniter boss and is used to remove salt deposits from the blades. It is important to note that when desalination washes are done together, it is essential that the compressor wash is performed prior to the compressor turbine wash.

Prior to performing the wash, the engine must be cooled to below 65°C, which means the engine must cool for a minimum of 40 minutes after its last operation. Once the engine is cooled, the procedure involves removing or opening the engine cowlings to expose the engine inlet screen and install the wash wand or ring. The wash wand or ring is then connected to the pressurized tanks or to the water supply. For some engines, the P3 air tube must be completely removed to avoid bending stress of one coupling, but Meridians have a fitting that is plumbed to the wand. Hence, it is a question of connecting the water supply to the fitting.

The switch ignition and aircraft bleed air is turned to the off position and a dry motor run is performed for no more than 30 seconds. When Ng reaches a minimum of 5 percent, the wash mixture is injected into the engine. Once Ng falls below 5 percent, cleaning solution is shut off. If a water/alcohol solution is used, an additional dry motor run must be performed once the starter has sufficiently cooled. The wash wand or ring is then removed from the inlet screen and the engine cowlings are closed or reinstalled.

The person performing the wash should then verify that wash fluid came out of the exhaust duct drain and should remove any obstruction from the drain fitting. Then the engine should be started and run at 80 percent Ng for at least one minute to completely dry the engine, check for air leaks and check acceleration. The engine is then shut down and the cowling is closed or installed.

Power recover washes and compressor turbine washes are more involved, but do not address the issue of inlet corrosion.

Although many people elect to have a qualified maintenance facility perform the engine washes, these washes are part of the preventative maintenance that an owner or operator can perform on their own. However, because of the complexity of the process, it is critical to have PWC documentation available for use while performing the wash. Also, it would be advisable to go through an engine wash with a qualified maintenance professional at least once prior to attempting an engine wash solo.

An experienced individual can perform the compressor turbine wash and the compressor desalination wash in about one and a half to two hours. If you elect to have your wash done at your favorite maintenance facility, you can plan on spending anywhere between $130 and $280 per wash, depending upon the experience of the facility.

On days that they fly, they would have to land, wait until the engine cools properly, perform the washes, dry out the engine and then put the airplane away. Because PWC recommends that the owner perform the washes after the airplane is used and that the owner not wait until the next day, that becomes problematic for the owner who returns in the evening, after the mechanic has left for the night. Meridian owners say it would be difficult to live up to the standards that have been established by PWC to avoid corrosion.

Many therefore simply hope that a reasonable alternative wash schedule, coupled with application of corrosion inhibitors will be an effective means of avoiding corrosion over the long haul.

Many Meridian owners, however, have very little confidence that undertaking a reasonable compressor wash schedule for the aircraft will resolve the issue. Indeed, there are several owners and maintenance personnel who suggest that, because the washes are designed to clean the CT and compressor blades and not the air inlet, any positive impact that the washes have will be incidental and there could be some negative impact as a result of water being caught between the engine air inlet and the aluminum screen.

Long-Term Outlook

The Piper Meridian is a very capable airplane and a joy to fly, but as with any high performance aircraft, it has maintenance requirements with which owners and operators must abide.

Neither PWC nor Piper will warrant corrosion, so it is even more important for owners and operators to be vigilant about corrosion. In addition, once corrosion forms, it only gets worse, so the longer that it is left to fester, the worse and more expensive the repairs are likely to be.

Moreover, so far neither PWC nor Piper has offered any long-term solution for owners, aside from the published schedule for compressor and compressor turbine washes. The owner/operator community has expressed concern that a serious analysis of the real cause of this specific problem has yet to be conducted, and hence, that the solution offered will truly prevent the recurrence of corrosion in the air inlet. That, in turn, creates the fear that the costly repairs that owners have undertaken will need to be repeated periodically.

Thus, at the very least, an aggressive schedule of compressor washes based upon the geographical base and usage of the airplane must be taken into the account. Until a better long-term solution to the problem is introduced, it is probably prudent for owners and operators to consider the cost of repairing the corrosion a possible cost with which they will be faced at some operating interval. T&T