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AirMaintenance UPDATE

The Magazine for Aircraft Maintenance Professionals

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Hot Off The Press: DIFFUSION BONDING

Rust-Busting: Corrosion Prevention

Transport Canada 'Feedback'

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Early Christmas for Maintenance Students

BACK IN OUR HIGH SCHOOL shop days we would have done anything to bring a vintage car project to class. Well, thanks to StandardAero that's basically what aviation maintenance students at Pittsburgh Institute of Aeronautics can now look forward to. StandardAero recently donated a classic TFE731-3 airplane engine to the PIA program, and a few weeks later, the vintage engine was mounted on an engine stand in the school's shop, where it will be used as a training guide for students working toward their airframe and powerplant licences.

"It's an early Christmas for our students and staff thanks to this complete engine donation from StandardAero," says Peg Skalican, Campus Director of PIA Myrtle Beach. "Understanding how and why engines have evolved throughout the years is a crucial component of aviation maintenance and engineering. Now our students will be able to study this classic engine type, which very few modern mechanics have firsthand experience with."

Originally manufactured by Garrett AiResearch in the 1970s, the TFE731-3 engine was developed for use in the Lockheed JetStar, which was the first line of dedicated business jets to enter service. Subsequent versions of this engine type were used on a number of aircraft, including the Learjet 55.

New aviation maintenance technicians are in extremely high demand as a large number of current mechanics are approaching retirement age. According to the 2021 Boeing Technician Outlook, the aviation industry will require 626,000 new maintenance technicians to join the global workforce between 2021-2040, with 132,000 of those technicians needed in North America alone. ■

— John Campbell, Editor

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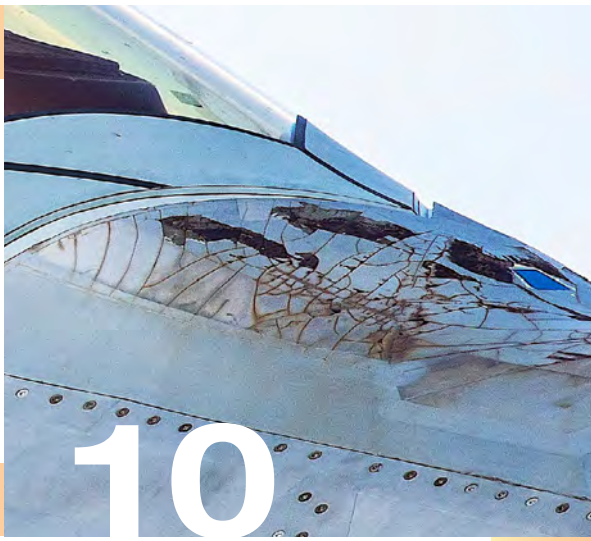

Features

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Upcoming Events

HAI HELI-EXPO 2022

THERE WILL BE something for everyone at HAI HELI-EXPO 2022, March 7–10 (exhibits open March 8–10), from networking opportunities with thousands of aviation professionals from around the world to fly-ins and fly-outs featuring the biggest names in the rotorcraft industry to more than 100 helicopter-focused educational opportunities. Additionally, the Expo hosts annual industry events, such as the HAI Helicopter Industry Career Fair, a military-to-civilian transition workshop for former military pilots and maintainers, the Salute to Excellence Awards, the HAI Safety Symposium, and much more.

After a year of virtual events, HAI HELI-EXPO 2022 will be your chance to resume business as usual. The Expo show floor is famous for hosting everything you need for your helicopter business, hosting 50-plus aircraft on the show floor as well as hundreds of exhibitors who provide the industry with products ranging from aircraft engines to flight crew uniforms and helmets. For a few days each year, HAI HELI-EXPO is the centre of the rotorcraft universe.

AÉRO MONTRÉAL INTERNATIONAL AEROSPACE WEEK

Aéro Montréal, Québec's aerospace cluster, is kicking off International Aerospace Week - Montréal 2022 in collaboration with the National Research Council of Canada (NRC) and the Palais des Congrès de Montréal. From April 4 to 7, 2022, Aéro Montréal will bring together all the players in the Québec, Canadian and international aerospace industry for a hybrid event (in-person and virtual).

The event will offer an innovative experience at the heart of the industry's new realities: the week will begin with the eighth edition of the International Aerospace Innovation Forum, on April 4-5, on the theme "Journey to the heart of sustainable air mobility." It will continue with a day dedicated to defence and security and space activities. Then on April 7, with Aéroportail: Vitrines 2022, the event is dedicated to promoting the aerospace industry's initiatives to its future generation of talent. ✪

International Aerospace Week is:
1,300+ participants
100+ international speakers
1,400+ B2B meetings

COMING EVENTS

PB Expo
March 3-4, 2022
Miami Beach, Florida
www.pbexpo.org

OAC Research & Technology Event
March 21, 2022
Toronto, Ontario
www.theoac.ca

Aéro Montréal
International Aerospace Week
April 4-7, 2022
Montreal, Quebec
www.aeromontreal.ca

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STCs & new products

Elastomer has broad temperature range

Greene Tweed's new **Fusion 665** ultra-low-temperature and chemically-resistant fluorocarbon elastomer meets and exceeds the new AMS7410 Aerospace Material Specification requirements. AMS7410 addresses the low temperature shortcomings of previous FKM elastomers that have historically struggled to provide reliable low temperature seal performance down to -53C and below. Fusion 665 has a broad temperature range (-57C to 232C), extremely low compression set, excellent chemical compatibility and abrasion resistance. These attributes address low temperature leakage control, which is particularly valuable in aircraft engine and hydraulic system seal applications. **www.gtweed.com**

Work bench provides proper support

With a gas spring adjustable back tilt range from upright to flat the **Eidos Model 112** from Eidos Ergonomics provides proper neck and back support for mechanics working overhead. It keeps a fully contoured position relative to the head and neck throughout its range of motion. Its durable construction features only top quality materials. All heavy wear parts are replaceable: seat, casters and gas cylinder. Heavy duty steel frame, six casters, and optional toolboxes make the Eidos Model 112 ideal for the harshest working environments. **www.eidosergonomics.com**

Power bits are heat treated

The new insert and power bit product lines from **Mayhew Steel** are available for a wide variety of fastener styles and are made with S2 Tool Steel – a shock-resistant material that can withstand high impact. The bits are heat treated to provide added strength and durability and they have precision tips. These new product lines are suitable for a wide range of applications – from simple everyday usage, to both intricate and heavy duty projects. Insert bits are designed for use with a screwdriver and/or can be used with various power tools. **www.mayhew.com**

Paint remover is effective on coatings

The product called **B&B 3095** from **Vantage Performance Materials** is a thickened paint remover designed to quickly remove chromated and non-chromated epoxy primers and polyurethane topcoats from aircraft exteriors. Also effective on polysulfide coatings, non-skid coatings and belly tape. B&B 3095 doesn't contain MeCl, acids, chromates, phenols or other hazardous solvents and has an 18-month shelf life. Vantage Performance Materials is a provider of cleaning solutions, coating removers and surface treatment solutions for military, space, commercial and general aviation markets. Products include aircraft paint and protective coating removers. **www.vantagegrp.com**

Snap knife allows more pressure on blade

KNIPEX Tools has introduced its new universal snap knife called the CutiX, and it features a stabilization bar that keeps the blade from bending for quicker cutting. The CutiX's extendable stabilization bar can be engaged or retracted based on application. The stabilization bar allows the user to apply more pressure directly on the blade. The CutiX also features a hardened steel pin to secure the blade. Constructed with a magnesium housing, the CutiX has non-slip gripping surfaces and two separate sliders: one for the blade and one for the stabilization bar. **www.knipex-tools.com**

Lubricant is designed for bearings

Cobra Solid Lubricant from Unique Technologies Associates is a proprietary, dry, graphite-based solid lubricant specifically designed for ball and roller bearings, conveyor wheels and conveyor components. Unlike common petroleum-based lubricants, Cobra Solid Lubricants cannot be washed out of bearings and exhibit extraordinary performance even in the most difficult applications. The characteristics of CSL products allow for great extremes in temperature without any change in starting torque or lubricity. **www.utausa.com**

To announce your STC or new product, email a JPG photo and a product description to John at: amu.editor@gmail.com

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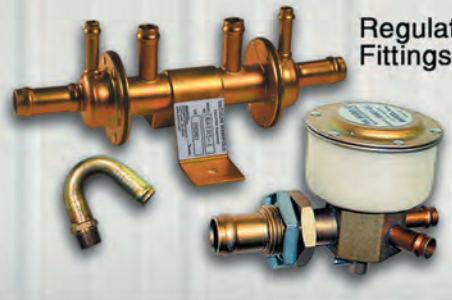

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ANOTHER STEP TOWARD ZERO CARBON GOAL

Airbus has begun delivery of all aircraft from its U.S. manufacturing facility in Mobile, Alabama with a blend of U.S.-sourced sustainable aviation fuel and conventional jet fuel. This is a further step in Airbus' long-term goal of developing a zero carbon-producing commercial aircraft by 2035. In November, Airbus began delivering aircraft with a SAF blend to some of its customers, gradually ramping-up to encompass all deliveries from the Mobile final assembly line. From now on, every aircraft delivered from the Airbus US manufacturing site will have SAF on board.

FIRST AIRBUS FOR CANADIAN FLYER

Canada Jetlines has announced the signing of a Definitive Lease Agreement for its first Airbus aircraft, with delivery expected by February 2022. The aircraft is an Airbus A320-200, listed under the manufacturer's serial number #4175, equipped with two CFM56-5B4/3 engines. Prior to delivery, the aircraft will be painted with Canada Jetlines livery and include installation of the new Recaro 3530 seats, with in-seat power and personal electronic device holder installed. The airline will also install the Flymingo Box system, which offers an aircraft-powered digital suite for wireless inflight entertainment options.

SCHOOL AIMS TO RESHAPE AERONAUTICS INDUSTRY

A new institute at the University of Waterloo is aiming to shape the future of the aeronautics industry. The Waterloo Institute for Sustainable Aeronautics, the first of its kind in Canada to take on the challenge of making air transport sustainable, will combine the work of 50 researchers from each of the university's faculties, and will be guided by an advisory committee that includes astronaut Chris Hadfield. "The creation of this institute comes at an exciting time for the university and at a critical juncture for the global aeronautics sector," said Jean Andrey, dean of the Faculty of Environment.

BIG YEAR FOR THE BELL 429

Bell began the year 2022 with a major milestone as its 429 rotorcraft surpassed 500,000 global fleet hours during corporate, HEMS, law enforcement and utility missions. Today, more than 400 Bell 429 aircraft serve law enforcement agencies and search and rescue organizations, like

the Swedish National Police, New York Police Department, Canadian Coast Guard, Air Zermatt's Swiss Alps rescue team and many more. Recently, the Bell 429 was selected to boost Kuwait's Ministry of Health emergency capabilities; entered into service with the New South Wales Police Force; completed its first delivery to Cambodia for corporate travel; and showcased at European Rotors 2021.

ONE MORE ACQUISITION FOR STANDARDAERO

StandardAero has agreed to purchase boutique asset management company PTS Aviation, a worldwide supplier of aircraft engines, engine components and engine inventory. The deal marks StandardAero's tenth acquisition since March 2015. Most recently, the company acquired Signature Aviation's Engine Repair and Overhaul business, an engine maintenance, repair and overhaul provider that includes brands such as Dallas Airmotive, H+S Aviation and International Governor Services. StandardAero has been providing CFM56-7B heavy maintenance and overhaul services for airlines worldwide from its 162,000-square-foot facility located in Winnipeg, Manitoba.

WORLD SPEED RECORD NOW CONFIRMED

Rolls-Royce reports its all-electric 'Spirit of Innovation' aircraft is officially the world's fastest all-electric aircraft, having set two new world records which have now been independently confirmed. On November 16, 2021, the aircraft reached a top speed of 555.9 kmh over three kilometres, smashing the existing record by 213.04 kmh. In further runs at the UK Ministry of Defence's Boscombe Down experimental aircraft testing site, the aircraft achieved 532.1 kmh over 15 kilometres – 292.8 kmh faster than the previous record. Both records have been officially verified by the Fédération Aéronautique Internationale, the World Air Sports Federation that controls and certifies world aeronautical and astronautical records.

PT6A IS GO-TO ENGINE FOR AMPHIBIAN

Pratt & Whitney Canada reports that Amphibian Aerospace Industries has selected the PT6A-67F turboprop engine to power its twin-engine G-111T amphibious aircraft as part of a Supplemental type certificate upgrade. The PT6A engine has logged more than 900 million hours of operation, with more than 50 years of experience in general aviation. The engine further benefits from a claimed 425 million flying hours—more flying hours than any other engine on the market, according to Pratt & Whitney Canada.

FAST-GROWING CARRIER PLACES BIG ORDER

Boeing and the fast-growing carrier Allegiant Air announced an order in early January for 50 737 MAX jets, with options for 50 additional airplanes. Allegiant selected two models – the 737-7 and 737-8-200 – in the 737 MAX family, which are said to provide the lowest seat-mile costs for a single-aisle airplane and high-dispatch reliability. Boeing says the 737-7 provides low-operating costs that enable carriers to open new routes with less economic risk. Compared to Allegiant's current fleet, the new 737 models will reduce fuel use and carbon emissions by 20 percent. ■

Feature

Rust-Busting: Corrosion Prevention Maintenance

Winter and early spring can be filthy seasons. Salt, ice, and temperature fluctuations are like magic carpets on which rust rides. The key to corrosion prevention is diligence. The Federal Aviation Administration's corrosion control circular AC 43-4B offers timely tips for fighting an enemy that truly never sleeps.

THE POSSIBILITY of an in-flight mishap or excessive down time for structural repairs mandates an active Corrosion Prevention and Control Program (CPCP) and corrosion inspection frequency, corrosion identification, and especially corrosion treatment continues to be the responsibility of the operator. The operational environment of the aircraft sets the type and aggressiveness of the program. Aircraft exposed to such environments as salt air, heavy atmospheric industrial pollution, or over-water operations, will need a more stringent CPCP than an aircraft operating in a dry environment.

On these pages we present a refresher on the nature of corrosion, the essentials of CPCP, and a hopefully helpful (though not exhaustive) list of the secret places corrosion loves to hide.

The Cycle of Maintenance

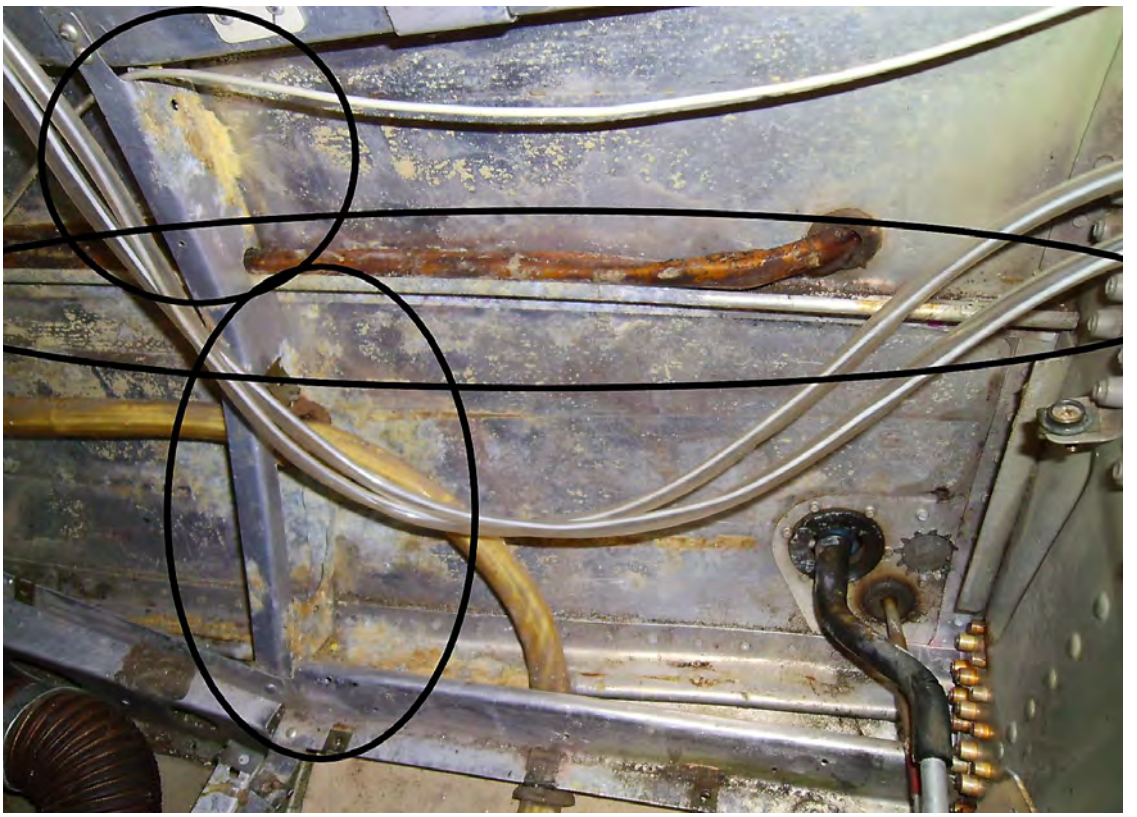
Operators must follow a constant cycle of cleaning, inspection, operational preservation, and lubrication to prevent corrosion. Prompt detection and removal of corrosion will limit the extent of damage to an aircraft and its components. The basic philosophy of a CPCP should consist of:

Opposite left: David Ellicks of the Air Force Corrosion Prevention and Control Office, inspects the intake area of an F-15 aircraft at Eglin Air Force Base.

Top: Affected external aircraft surfaces are readily visible or available for inspection and maintenance.

Right: Corrosion is a natural phenomenon which attacks metal by chemical or electrochemical action.

1. Personnel adequately trained in recognizing corrosion, including conditions, detection and identification, cleaning, treating, and preservation;
2. Thorough knowledge of corrosion identification techniques;
3. Proper emphasis on the concept of all-hands responsibility for corrosion control;
4. Scheduled corrosion inspections;
5. Aircraft washing at regularly scheduled intervals;
6. Routine cleaning or wipe down of all exposed unpainted surfaces;
7. Keeping drain holes and passages open and functional;
8. Scheduled inspections, removals, and reapplications of preservation compounds;
9. Early detection and repair of damaged protective coatings;
10. Periodic thorough cleaning, lubrication, and preservation;
11. Prompt corrosion treatment after detection;
12. Accurate record keeping and reporting of material or design deficiencies; and
13. Use of appropriate materials, equipment, and technical publications.



Examine and replace all flexible hose assemblies with chafing, weather checking, hardening, discolouration, evidence of fungus, and torn weather protective coatings or sleeves.

Corrosion is a natural phenomenon which attacks metal by chemical or electrochemical action and converts it into a metallic compound, such as an oxide, hydroxide, or sulphate. Corrosion is different from erosion, which causes destruction by mechanical action. The corrosion occurs because metals tend to return to their natural state. Noble metals, such as gold and platinum, do not corrode since they are chemically uncombined in their natural state. Four conditions must exist before corrosion can occur:

1. Presence of an anode, or a metal that will corrode;
2. Presence of a cathode, a dissimilar conductive material which has less tendency to corrode;
3. Presence of an electrolyte, a conductive liquid; and
4. Electrical contact between the anode and cathode, which is usually by metal-to-metal contact, or through a fastener.

There are numerous corrosion problem areas common to most aircraft and maintenance personnel need to clean, inspect, and treat these corrosion-prone areas more frequently.

The following is a list of such areas and while it's not intended for a specific aircraft, it can be used to set up a maintenance inspection program.

Exhaust Trail Areas

Both jet and reciprocating engine exhaust gas deposits are very corrosive. Inspection and maintenance of exhaust trail areas should include removal of fairings and access plates in the exhaust gas path. Gaps, seams, hinges, and fairings are areas where exhaust trail deposits may be trapped and normal cleaning methods cannot reach these areas. Exhaust deposit buildup on the upper and lower wing, aft fuselage, and in the horizontal tail surfaces will be considerably slower and sometimes completely absent on certain aircraft models.

Battery Compartments and Battery Vent Openings

In spite of protective paint systems and extensive sealing and venting, battery compartments continue to be corrosion problem areas. Fumes from overheated battery electrolyte are difficult to contain and can spread to internal structures where unprotected surfaces can come under corrosive attack. For lead-acid batteries, frequent cleaning and neutralization of acid deposits with sodium bicarbonate solution will minimize corrosion.

If the battery installation includes external vent openings on the aircraft skin, these areas should be included in inspection and maintenance procedures. If aircraft have batteries with electrolytes of either sulphuric acid or potassium hydroxide, electrolyte leakage will cause corrosion. Consult applicable maintenance manuals to determine the battery type installed and recommended maintenance practices. Clean nickel cadmium compartments with ammonia or boric acid solution, dry thoroughly, then paint with an alkali-resistant varnish.

Above: Direct chemical attack in a battery compartment.

Left: During inspection pay special attention to attaching hardware, such as bolts or pins.

Below: The operational environment of the aircraft sets the type and aggressiveness of the CPCP program.

Lavatories, Buffets, Galleys, Doorways and Cockpit Floorboards

These areas, particularly deck areas behind lavatories, sinks, and ranges, are potential trouble areas where spilled food and waste products may collect. Even though some contaminants are not corrosive, they will attract and retain moisture, and promote corrosive attack. Pay particular attention to bilge areas and aircraft structure located under galleys and lavatories. Clean these areas frequently and maintain protective sealant and paint finishes.

Bilge Areas

On all aircraft, the bilge area is a common trouble area. The bilge is a natural sump or collection point for waste hydraulic fluids, water, dirt, loose fasteners, drill chips, and other debris. Residual oil quite often masks small quantities of water which settle to the bottom and set up a hidden potential corrosion cell. Except for water displacing corrosion-preventing compounds, keeping bilge areas free of extraneous material, including water and oil, will insure the best protection against corrosion. A good vacuum cleaner and clean wiping cloths are handy tools to clean such areas.

Wheel Wells and Landing Gear

The wheel well area probably receives more punishment than any other area of the aircraft. It is exposed to mud, water, salt, gravel, and other flying debris from runways during flight operations. Aircraft wheels and wheel well areas should receive frequent cleaning, lubrication, and paint touch-up. Because of many complicated shapes, assemblies, and fittings in the area, complete coverage with a protective paint film is difficult, and preservative coatings tend to mask trouble rather than prevent it. Do not use preservative coatings on landing gear wheels because of the heat generated from braking.

During inspection of this area, pay particular attention to these trouble areas:

- Aluminum and high-strength steel.
- Exposed surfaces of struts, oleos, arms, links, and attaching hardware, such as bolts or pins.
- Axle interiors.
- Exposed position indicator switches and other electrical equipment.
- Crevices between stiffeners, ribs, and lower skin surfaces, typical water and debris traps.
- Magnesium wheels, particularly around bolt heads, lugs, and wheel web areas.
- Exposed rigid tubing, especially at "B" nuts and ferrules under clamps and tubing identification tapes.

External Skin Areas

External aircraft surfaces are ordinarily covered with protective finishes, and operators can also apply paint coatings. Affected external aircraft surfaces are readily visible or available for inspection and maintenance. Much emphasis has been given to

The possibility of an in-flight mishap or excessive down time for structural repairs mandates an active Corrosion Prevention and Control Program.

Aircraft painter applying an anti-corrosion formula.

these areas in the past, and maintenance procedures are well established. Even here, certain configurations or combinations of materials become troublesome and require special attention to avoid serious corrosion difficulties.

Water Entrapment Areas

Corrosion will result from entrapment of moisture. Except for sandwich structures, design specifications usually require that the aircraft have low-point drains in all areas where moisture and other fluids can collect. In many cases, these drains are ineffective either because of location or because they are plugged by sealants, extraneous fasteners, dirt, grease, and debris. Potential entrapment areas are not a problem when properly located drains are functioning and the aircraft has a normal ground attitude and is resting on its landing gear. Plugging a single drain hole or altering the level of the aircraft can result in a corrosion problem if water becomes entrapped in one of these "bathtub" areas, and we recommend a daily inspection of low-point drains.

Engine Frontal Areas and Cooling Air Vents

Constant abrasion by airborne dirt and dust, bits of gravel from runways, and rain all tend to remove protective surfaces from engine frontal areas and cooling air vents. Radiator cooler cores or reciprocating engine cylinder fins, designed for heat dissipation, may not be painted. Engine accessory mounting bases usually have small areas of unpainted magnesium or aluminum on machined mounting surfaces. With moist and salt or industrial pollutant-laden air constantly flowing over these surfaces, they are prime sources of corrosive attack. Inspection of such areas should include all sections in the cooling air path, with special attention to obstructions and crevices where salt deposits may build up during marine operations.

Electronic Package Compartments

These areas are cooled by ram air or compressor bleed air and are subject to the same conditions as engine and accessory cooling vents and engine frontal areas. While the degree of exposure is less because of a lower volume of air passing through the compartment and special design features preventing water formation in enclosed spaces, this is still a trouble area needing special attention.

As circuit breakers, contact points, and switches are extremely sensitive to moisture and corrosive attack, inspect for these conditions as thoroughly as the design permits. Most corrosion on avionic equipment is similar to basic airframe structure corrosion, but there is a difference: minute amounts of corrosion in avionic equipment can cause serious degradation or complete failure, while similar corrosion on larger structures would go unnoticed.

Smog, smoke, soot, and other airborne contaminants are extremely corrosive to exposed avionic equipment. Many fumes and vapours emitted from factories or industrial complexes are highly acidic and greatly accelerate corrosion. An example is the corrosive effect of ozone, a product of welding machines and large electrical motors. Complete degradation of rubber seals and damage to delicate components have occurred in equipment stored near ozone-producing equipment. Avionic shops and storage areas should have a filtered air conditioning system to help remove ozone from the enclosed shop or storage area.

Another man-made atmosphere is the aircraft environmental control system. These systems direct cooling air to the equipment, and may include a filter system that extracts moisture or contaminants from air entering the equipment. Always replace or clean filters, or eliminate leaky environmental seals, to prevent buildup of moisture or contaminants that could cause a corrosive atmosphere inside the equipment.

Miscellaneous Trouble Areas

Examine and replace all flexible hose assemblies with chafing, weather checking, hardening, discolouration, evidence of fungus, and torn weather protective coatings or sleeves.

Trimmed edges of sandwich panels and drilled holes should have some type of corrosion protection. Recommended is a brush treatment with an inhibitor solution or applying a sealant along the edge, or both. With a sealant, fill gaps or cavities where moisture, dirt, or other foreign material can settle. Adjacent structures, not the sandwich, should have sufficient drainage to prevent moisture accumulation. Seal damage or punctures in panels as soon as possible to prevent additional moisture entry, even if permanent repair must be delayed.

Control cables may present a corrosion problem whether of carbon steel or stainless steel construction. Bare spots in the preservative coating is a main contributing factor in cable corrosion. Determine cable condition by cleaning the cable assembly, inspecting for corrosion, and applying an approved preservative if no corrosion is found. If external corrosion is found, relieve tension on the cable and check internal strands for corrosion. Cables with corrosion on internal strands should be replaced. Pay particular attention to sections passing through fairleads, around sheaves, and grooved bell-crank arms. External corrosion should be removed by a clean, dry, coarse rag or fibre brush. After complete corrosion removal, apply a preservative.

Topcoating materials in integral fuel cells, such as Buna-N, polyurethane, or epoxy, repel fuel but can absorb moisture through the topcoating materials and sometimes cause pitting or inter-granular corrosion on aircraft structural parts. Microorganisms that live in water entrained by fuel, particularly jet propellant fuel types, feed on fuel hydrocarbon and hydrocarbon-type elastomeric coating materials.

Excreted organic acids and dead microorganisms act as a gelatinous acidified sponge which can deteriorate integral tank coatings and corrode the aircraft structure. Minimize microbial corrosion by preventing as much water contamination of the fuel as possible with well-managed storage facilities, adequate fuel filtration, and drainage of water contamination from integral fuel cells. This drainage keeps the water moving and reduces development of microorganism colonies. Reduce microorganic activity by using a biocide additive such as "Biobor JF" or equivalent. Use manufacturer instructions to determine solution strength and application frequency.

Electrical connectors or components may be potted with a sealing compound for improved reliability, and to prevent moisture entrance into connectors where wires are attached to pins. Use rubber O-rings to keep moisture out of the mating area of pin connections and prevent loss of pressurization in compartments containing bulkhead connectors. Moisture intrusion into electrical connectors can cause corrosion and an electrical failure. Disconnect and disassemble suspected plugs, clean with a solvent, and inspect for corrosion.

Severe corrosion damage to rear pressure bulkheads below the floor may occur as a result of contamination by fluids. Inspection for rear bulkhead corrosion may require extensive disassembly of components and fixtures to enable a thorough visual inspection. When inspection access holes are available, inspection by fiber optics is useful. Regular inspections of the rear pressure bulkhead, both front and rear faces, below the floor level should prevent serious corrosion buildup between the bulkhead and periphery doubler at the floor level. Such corrosion could weaken the bulkhead skin and lead to sudden cabin pressure loss.

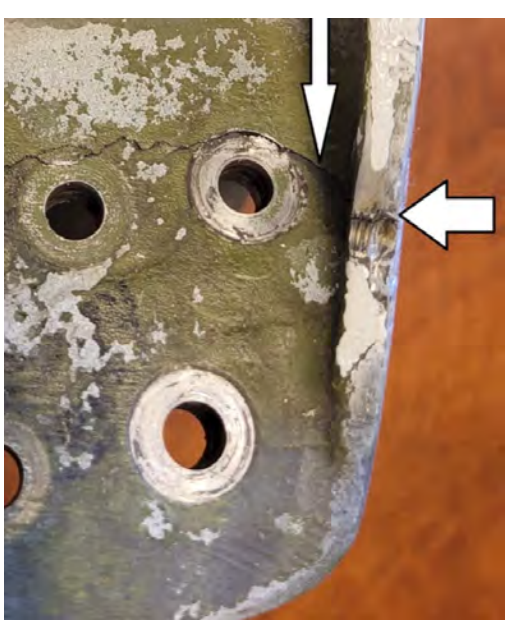
Some older aircraft develop delaminations in cold-bonded joints. Corrosion between the delaminated surfaces stems from moisture intrusion along edges of mating parts or around fasteners securing mating parts together. Localized bulging of a skin or internal structural components, usually around the fasteners, is the first indication of a corrosion problem.

Skin cracks or dished or missing fastener heads may also indicate severe corrosion in bonded joints. Corrosion occurring between skins, doublers, and stringers or frames will produce local bulging or pulled rivets. Corrosion that occurs between the skins and doublers or tear straps away from a backup structure, such as stringer or frame, will not produce local bulging. An external low frequency eddy current inspection should determine the extent of corrosion in the skin. Above all, keep in mind that corrosion is an insidious foe that never takes a shift off. ■ *(With Federal Aviation Administration files.)*

TC Feedback

The following are selections of Canadian Aviation Service Difficulty Reports originally published as "Feedback" by Transport Canada.

Above: Beech King Air. Below: Right-hand horizontal stabilizer bracket crack



REPORTS AND COMMENTS

Report: Beech King Air A100 Horizontal Stabilizer Bracket Cracked

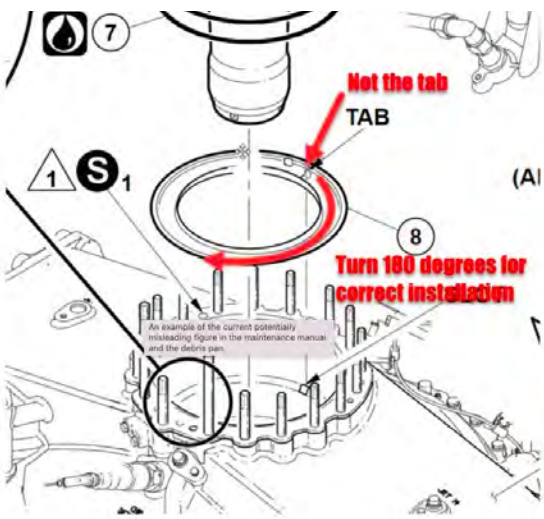
Subject:

During routine inspection, the bracket between the horizontal stabilizer, fuselage, and vertical stabilizer was found cracked. This may have been caused by a screw from the tail cone coming into contact with the bracket, causing a stress riser.

Transport Canada Comments:

Care must be taken when installing the tail cone of these aircraft. In at least three cases, damage to the horizontal stabilizer bracket resulting in a crack had been caused by the use of improper hardware when installing the tail cone. Similar findings have also been reported on model 99 series aircraft.

As aeroplanes age, it is important to take your time to



Above: Bell 429.

Left: An example of the current potentially misleading figure in the maintenance manual and the debris pan.

properly inspect all areas in order to find damage that could progress to a failure of the part. Proper lighting is important so that you can see what you are inspecting.

Report: Bell 429
Main Rotor Transmission Debris Pan Inspection

Subject:

An operator found one debris pan incorrectly installed, which could prevent the mast chip detector from detecting metal contamination from the mast bearing. After Bell investigated, it was found that the maintenance procedure was clear and accurate, however the figure in support of the procedure could be misleading. Consequently, the maintenance manual figure will be updated to avoid repeating such an issue.

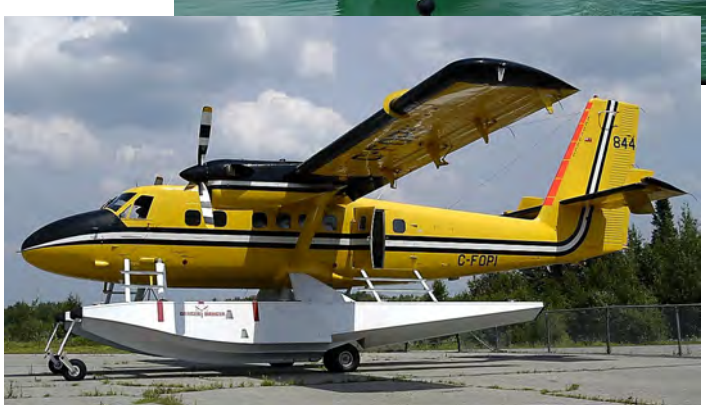
Transport Canada Comments:

The debris pan has a tab and a cutout, an incorrect installation of the debris pan is when the tab of the pan is not properly aligned with the slot in the main rotor transmission. Following their investigation, Bell published Alert Service Bulletin (ASB) 429-21-54 to provide instructions for completing a one-time inspection, and a figure showing the correct installation of the oil debris pan. The ASB states that incorrect installation could result in the lubricating oil not being supplied to the mast chip detector and to the mast spline from the #13 oil jet. In addition to the ASB, Bell will be revising the potentially misleading figure currently published in the model 429 maintenance manual. Transport Canada, Civil Aviation (TCCA) encourages owners, operators and maintainers to review and accomplish ASB 429-21-54 to verify the correct installation of the debris pan.

Report: De Havilland DHC-6-300
Service Difficulty Reports Involving Supplemental Type Certificate (STC) and/or Part Design Approval (PDA) and/or Parts Manufacturing Approval (PMA) Parts.

Subject:

The main landing gear compression blocks on the affected DHC-6-300 were found to be not only compressed, but very deformed. The blocks were noted, during routine inspection,



Front and side views of a De Havilland DHC-6-300

to be sliding off the upper and lower platen surfaces, and no longer of a rectangular shape. The total time in service was 665.4 hours. The block serial numbers are 10249, 10250, 10251, and 10252. All blocks will be replaced at this time.

Transport Canada Comments:

Although this Service Difficulty Report (SDR) was issued against the DHC-6-300 aircraft model, the part number listed for the main gear compression blocks is not an Original Equipment Manufacturer (OEM) produced part, as identified by the prefix TB before the Viking Air Limited part number C6U114033.

Transport Canada Civil Aviation would like to remind submitters that when a reportable failure, malfunction or defect is detected that affects a part, component or system of an aircraft, engine or propeller that was supplied or modified as part of an approved modification, such as a Federal Aviation Administration (FAA) PMA, TCCA PDA, or as in this case, a TCCA STC, it is important for the SDR to clearly identify that the affected product or system was modified, and the applicable approval number. This will provide the necessary information in order for TCCA to forward the SDR to the appropriate certificate holder and determine if any corrective action is required by the certificate holder and/or TCCA.

Report: Honeywell TPE331-10 Incorrectly Set Turbine Rotor Rivets (opposite page) >

Subject:

After routine maintenance at an outside repair station, the propeller was turned to prepare for propeller removal. It was observed that the engine would only rotate slightly due to part of the rotating group getting caught on something internally.

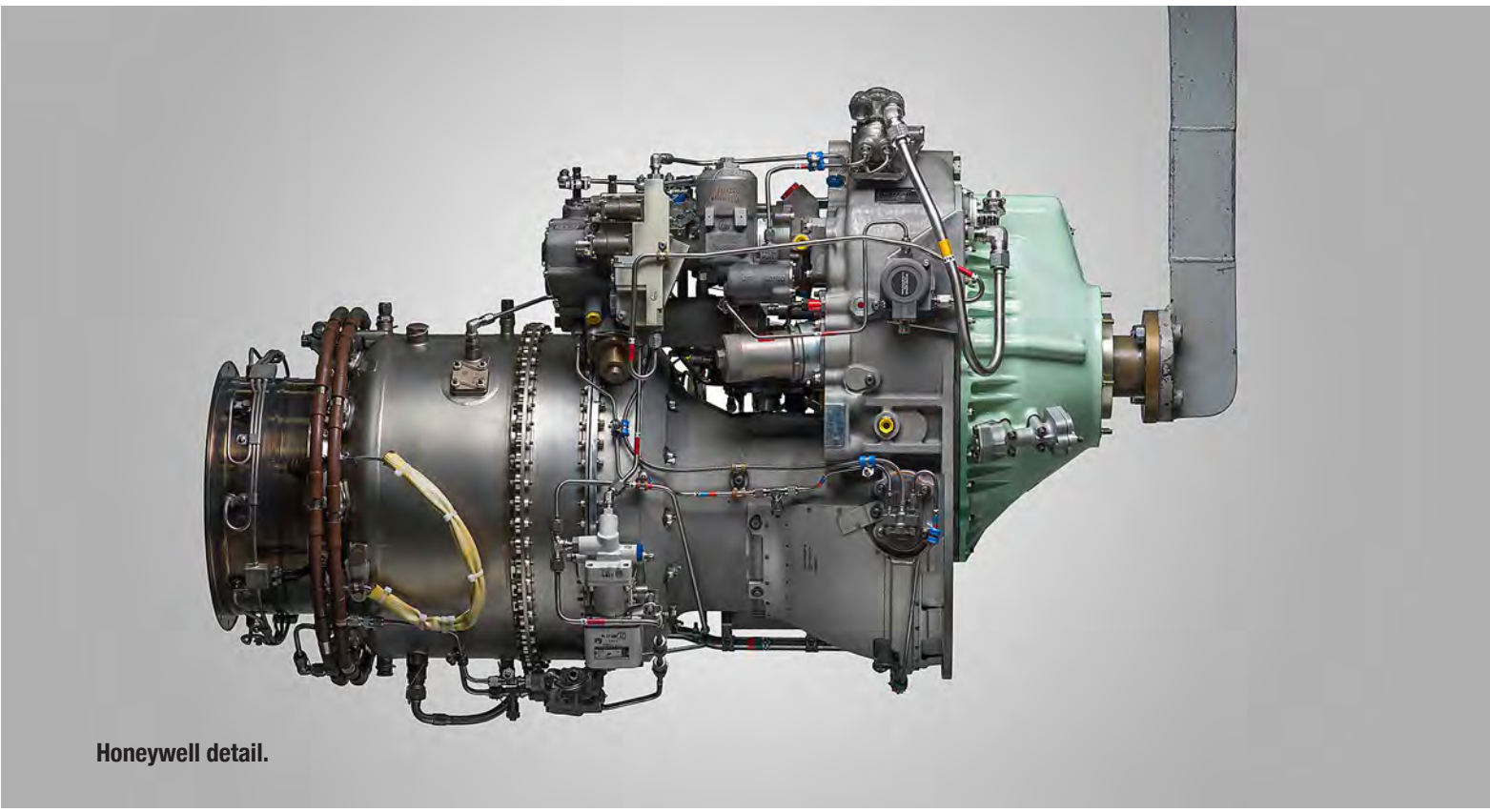
The engine was inspected and it was found that some of the retaining pins (rivets) holding the blades of the second stage turbine (Part Number 3102106-10) had fallen out. After some research it was noted that the rivets were out of dimensions per Honeywell manuals.

The engine is being inspected at an approved overhaul facility and the second stage turbine is in the process of being replaced.

Transport Canada Comments:

Attention to detail is of paramount importance when conducting complex maintenance tasks such as engine assembly. Manufacturers' recommendations must be followed (CAR 571 Standard 571.02). This is particularly important when the final assembly is hidden from view and not easily inspected.

Fortunately this resulted in a ground incident rather than an inflight emergency.



Honeywell detail.

Honeywell. Rotor assembly with rivets that had fallen out due to incomplete setting.

Heads-Up: Pilatus PC12 47E
Bleed Air Overtemperature Switch – Revised Test Procedure

Subject:

The test procedure listed in Aircraft Maintenance Manual (AMM) 12-B-21-40-06-00A-903A-A was carried out on the bleed air overtemperature switch. According to the test procedure, the switch is supposed to activate at 290ºC , ± 6ºC.

Pilatus PC12 47E

The installed switch failed, as did a new one that was installed. Multiple new switches were checked, and all were activated at 325°C or higher. Pilatus, the aircraft manufacturer, was contacted and issued Technical Memo TM-12-006654, which revised the test procedure. Under the provisions of the new test procedure, only the original switch passed, the other (all new) switches still failed. It is suspected that there is a bad batch of switches. As there is no requirement to test a new switch prior to installation, it is possible that a faulty switch could be installed.

Transport Canada Comments:

Pilatus has determined the problem to be the testing procedure and equipment defined in the AMM. The Quick Cal temperature calibrator that is prescribed does not heat the temperature switch to the temperature displayed. Therefore, as described in the TM-12-006654, the calibrator must be set to a higher temperature.

Here is an extract of the Test from the revised PC-12/47E AMM (for reference only):

- 12-B-21-40-06-00A-903A-A OVERTEMPERATURE SWITCH -Adjustment/Test
- §2.2.6 Changed from 283°C to 289°C.
- §2.2.8 Changed from 296°C to 330°C
- §2.2.10 Changed from 290°C±6°C to between 290°C and 330°C

The purpose of this Feedback article is to advise Pilatus PC-12 aircraft operators and maintainers of a revised procedure to test the bleed air overtemperature switch. Please follow the new procedure prescribed within the latest AMM revision.

Report: Pratt & Whitney – Canada PT6A-67P Leaking Propeller Shaft Seal

Subject:

On July 11, 2020 the propeller shaft seal was replaced due to leaking, and an engine ground run and leak check were completed. On July 13, 2020 the aircraft took off from the airport and completed a turnback due to oil on the windscreen and the engine cowling. Maintenance replaced the faulty propeller shaft seal on July 15, 2020. During the replacement of the faulty shaft seal, a buildup of seal material on the mating surface of the seal was noted and grooves on the aft side of the seal mating surface had worn off.

Transport Canada Comments:

In this event, an oil leak was found, and a seal replacement was carried out by maintenance personnel. Unfortunately, the seal failed on the next flight even though ground runs had been performed after its replacement. Further inspection found a buildup of seal material on the mating surface, which probably resulted in the sealing grooves being worn off and another oil leak.

An investigation into the root cause could not rule out the possibility of both seals being defective. However, it was determined that improper maintenance practices likely contributed to the failure of the second seal. It was found that the replacement seal was not repositioned according to the maintenance manual instructions. A third seal was installed, and the aircraft returned to service.

With the demands of meeting schedules and deadlines in a very competitive market, many tasks are at risk of being rushed to completion. In this circumstance, it appears that a full inspection of the area including mating surfaces may not have been completed prior to installation and repositioning of the propeller shaft seal. Transport Canada Civil Aviation (TCCA) reminds maintenance personnel that they have a responsibility to accomplish tasks in accordance with the appropriate standards of airworthiness and to remain vigilant for human factor issues that may impact the quality of their work. ■

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PACIFIC

Pacific AME Association

Meet Our Vice President

Alisha Sohpaul
Alisha is a licensed M1 & M2 Aircraft Maintenance Engineer and is proud to be one of the two percent of female AMEs in Canada. She is not only the first female member to join PAMEA but also the first to serve on the Board. Alisha is currently the Person Responsible for Maintenance (PRM) at Iskwew Air and helped launch the Aircraft Maintenance Organization (AMO) in March 2021.

She has been working in the industry for the past seven years and is passionate about giving back to the industry by encouraging young females to pursue careers in aviation. Mentorship has had a huge impact on Alisha and has led her to also become a mentor with Elevate Aviation. Here she is able to relate with other women and share her journey. Alisha also serves on the Youth Engagement Committee with the British Columbia Aviation Council. In her free time she enjoys hiking, cycling, backpacking around the world, playing sports and meeting new people.

www.pamea.ca

WESTERN

Western AME Association

Website Now Under Maintenance

The WAMEA website is currently undergoing maintenance and will be back soon!
For any inquiries, the usual communication methods are still in place:
Email: info@wamea.com or president@wamea.com
Phone: 587-713-WAME (9263)

While the WAMEA website is undergoing maintenance, please take the opportunity to peruse the National AME Association website for your professional interests at:
http://www.amec-teac.ca

Thank you for your patience,

Greg Andersen
President, Western AME Association
www.wamea.com

www.wamea.com

CENTRAL

Central AME Association

CAMEA Rookie of the Year Awards

Previously known as the NAASCO Outstanding AME Award. This award recognizes any AME or manager holding an AME licence in Manitoba, Saskatchewan, and Northern Ontario that has performed an extraordinary act of service or has shown leadership, dedicated technical service and has been active in nurturing and training other mechanics.

Do you know someone that should be thanked? Do you know an Outstanding AME? Nominate someone today!

Save the Date: annual Aviation Symposium
CAMEA will host the 26th Annual Aviation Symposium on March 3-4, 2022. The venue for this event is Canad Inns Polo Park in Winnipeg, Manitoba.

www.camea.ca

AME Association of Ontario

c/o Skyservice F.B.O. Inc., PO Box 160, Mississauga, Ontario L5P 1B1
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email: association@ame-ont.com website: www.ame-ont.com

ONTARIO

Some words to assist us

It has been an eventful couple of years with all of us having to manage through a worldwide pandemic. Some of us retired folks reflected on how it was during World War II and its aftermath. The word resilience comes to mind, then and now.

My family, three children and six grandchildren, were impacted by the latest version of the pandemic in different ways. My senior grandson, playing for the Queens University ice hockey team, came down with COVID along with many others in Kingston Ontario. This 21-year-old, in superb physical shape, double vaccinated, felt flu-like symptoms, headache, tiredness and went to bed for three days. After which he regained his appetite and energy and was able to fly to Vancouver to join his family for Christmas.

Everyone has been impacted personally and professionally as a result of the COVID-19 pandemic. In order to help protect yourselves, family, friends, and the community, AME members should follow public health guidelines, including getting vaccinated (including boosters), wearing a good quality mask in public settings, and minimizing social interaction.

You can find the latest information on COVID-19 at this website: www.publichealthontario.ca/en/diseases-and-conditions/infectious-diseases/respiratory-diseases/novel-coronavirus

All this to say, be careful and follow the latest Ontario Government advice. Be kind to yourself and others. Keep up on the news to help you and your families do the right thing. Be safe.
With respect,

John Longo
President, AME Association of Ontario

www.ame-ont.com

Atlantic AME Association

ATLANTIC

ARAMC 2022

It's time for our first ARAMC conference in three years! Due to COVID we had to cancel ARAMC 2020 and ARAMC 2021. Our ARAMC 2022 committee has started planning for our upcoming conference. Mark these dates: April 20-22, 2022. The conference will be held at the Westin Hotel, Halifax, Nova Scotia. We will follow the standard format. Booth set up on Wednesday the 20th, followed by Meet and Greet that evening. Thursday and Friday will be two days of information sessions along with a room full of exhibitors.

When we had the conference here in Halifax in 2018, we held a Skills Competition. This went over very well; we will be doing the same in ARAMC 2022. We also held an Industry Social in the exhibit hall, again, we plan to do the same. We are always looking for new ideas, new presenters, new topics and new displayers. If you know of anyone that might be interested in presenting or exhibiting, please pass along our contact information. If there is something you would like to see, please let us know.

Our displayers' packages will be going out in a few weeks. We had hoped to have a tentative program by mid-January, and will post on the website. Delegate packages were scheduled to go out at the end of January. If you would like to receive a package, please let us know! Both the displayer package and the delegate package will be available on the website once they are available.

As well please note that the AME Association will be conducting a HF course on Wednesday April 20. This will be a full day course and meets the requirements for both initial and recurrent training. Watch for further info on our website.

Co-chair – Anneke Urquhart – email anneke.urquhart@sobeys.com
Co-chair – Neil Harding – email neil.harding@impaerospace.com
Displayers – Gerald Mallon – email Gerald.mallon@flyjazz.ca
Speakers – Pat Smith – email psmith@gastops.com

Thank you! Hope to see you at the ARAMC 2022
www.atlanticame.com

CENTRAL OHIO

Central Ohio PAMA

2022 Ohio Aviation Maintenance Symposium

On December 15th, FAA Safety Inspector Paul Gillenwater led a discussion with COPAMA board members, other FAASTeam Inspectors from Cleveland and Cincinnati FSDOs, Eastland Career Center Instructor Alex D'Ettorre and Instructors Deem and Everett from C.S.C.C. Aviation Maintenance Technology to discuss holding the 2022 Ohio Aviation Maintenance Symposium at that site. The Symposium date will be March 15th at the Eastland Career Center which is located at 4465 S. Hamilton Road, Groveport, Ohio 43125.

The change of venue addresses costs and COVID issues and gives exposure of the Aviation Maintenance Community to the students at E.C.C. engaged in their Aviation Pathways Program. Many past vendors have already signed on as Booth Displays and Presenters at the event. E.C.C.'s Aviation Pathways Program exposes their students to Piloting, Maintenance, A.T.C., Airport Management and Drone training to pass the Part 107 UAS Certification. They get a well rounded idea of aviation so they can decide which career path to choose after High School graduation.

The Symposium will be held in their Engineering Technologies Center recently opened in August 2021. Along with the Aviation program which provides training for up to 30 Junior and Senior students from affiliated regional High Schools, the building houses Welding, Pre-Engineering, Computer Controlled Manufacturing, and other technical courses for High School and Adult continuing education classes in the evening.

The Center will be on Spring Break so acres of parking are available along with local restaurants and planned food trucks for lunch. Attendees should plan their choice of food source or bring their lunch. We will update our website with information when plans are finalized.

www.copama.org

SOCAL

SoCal PAMA Chapter

Who We Are

The purpose of SoCal PAMA is to promote a high degree of professionalism among aviation maintenance personnel; to foster and improve methods, skills, learning, and achievement in the field of Aviation Maintenance; to conduct local meetings and seminars; to publish, distribute, and disseminate news, technical bulletins, journals, and other appropriate publications dealing with the trade of Aviation Maintenance; to collaborate with other organizations in aviation in the queries of governmental agencies pertaining to maintenance rules and guidelines.

www.socalpama.org

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Read on if joining dissimilar metals sounds like alchemy or, at best, voodoo science.

Titanium is used in manufacturing the structural components of wings. Below: Skins for hydraulics systems are created through metal diffusion bonding.

✶ HOT OFF THE PRESS ✶

Diffusion Bonding

METAL DIFFUSION BONDING or diffusion welding is a solid state joining process for blending dissimilar materials. The process has been used most extensively in the aerospace industries for joining materials and shapes that otherwise could not be made. For example, titanium is used in manufacturing the structural components of wings as well as skins for hydraulics systems in aircraft, various components of aircraft engines and the cabins of spacecraft, where its qualities are irreplaceable.

Unfortunately, welding of titanium and titanium alloys is difficult as they are highly chemically reactive at high temperatures and tend to oxidize at very low partial pressures of oxygen. During the welding process, titanium alloys pick up

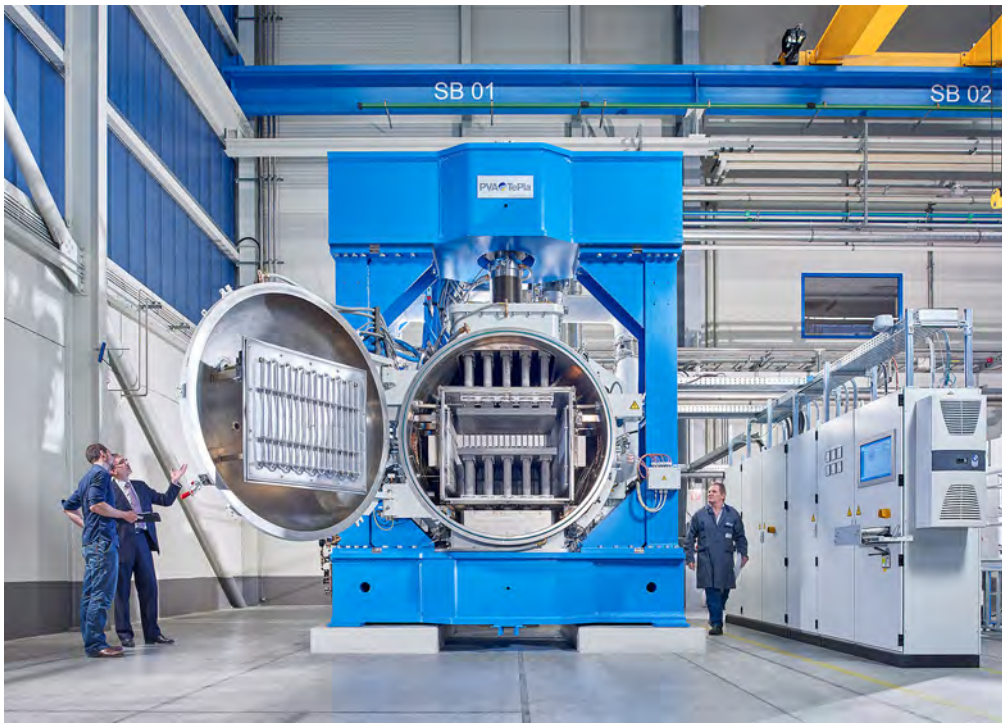
oxygen and nitrogen from the atmosphere very easily. As a result, diffusion bonding is a preferred joining method for titanium and titanium alloys.

There is probably no other commercially viable materials joining process that can produce such consistent results today. The applied pressure induced by a hot-press tool, combined with software and loop-back sensors for precise control to within micrometer accuracy, can produce constant pressure over several square feet of area for a component assembly. As a result, this technology has attracted the interest of design engineers in the aerospace industry.

With such a high degree of process control, the diffusion bonding process is increasingly used to join dissimilar metals. Commercial processes of interest are titanium to iron-nickel alloys, titanium alloys to stainless steel, and even some aluminum to metal applications. The process also enables coupling between different alloys in the same material group, such as mild steel, tool steel, and Metal-Matrix Composites.

To successfully use diffusion bonding, an understanding of the complexities of the interface and its effect on the chemical and thermo-mechanical properties of the bond is required. However, with the industry's traditional focus on welding and brazing, there has been minimal formal education on diffusion bonding, according to Thomas Palamides, Senior Product & Sales Manager - Industrial Furnaces, PVA TePla AG, a global manufacturer of industrial furnaces and PulsPlasma nitriding systems.

"Combining the beneficial properties of different metals is the main reason to explore diffusion bonding. However, when manufacturers reach out [to us about it], they often understand little about how the parts should be designed, prepared, or handled. They may have questions about process data and need guidance on issues such as heating, cooling, and pressing rates," says Palamides.



Advances in high vacuum hot presses now allow superior pressure control and rapid cooling systems to improve the bond.

THE BENEFITS OF DIFFUSION BONDING

The importance of designing a dissimilar metal joint often lies in a desire to expose the correct metal surface to specific environmental conditions where a single alloy may not perform as well. Another reason is to introduce material systems that are lighter in weight or provide a level of corrosion resistance that can only be achieved by "packaging" dissimilar metals.

Diffusion bonding also has tremendous potential applications for conformal cooling. The concept is to bond layers of sheet metal that contain machined channel/microchannel structures. When combined, the channels can provide for cooling or heat dissipation. The layers can be bonded up to a stack height of 600mm in the MOV diffusion bonding press, retaining the strength as the parent materials.

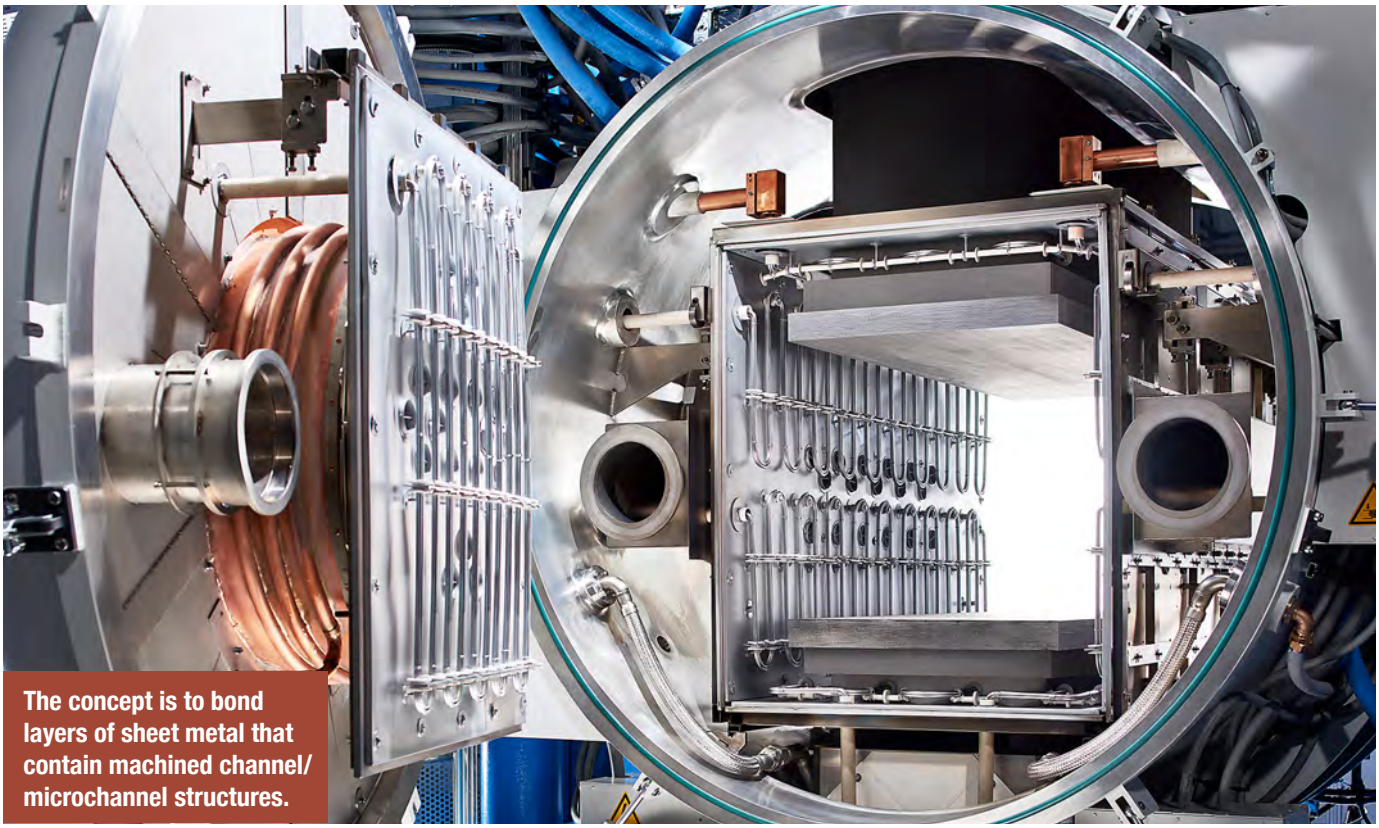
Another application related to conformal cooling is for plastic injection molds made in two-layer designs of low alloyed tool steel with stainless steel such as STAVAX.

UNDERSTANDING DIFFUSION BONDING

Academia has researched dissimilar joining for decades, and much of the focus has been on high-performance materials like titanium alloys. According to Palamides, expanding beyond commercially pure (CP) titanium, one often finds the existence of an intermetallic layer at the mating interface after processing. "The influence of the solute elements, such Cu, Ni, and Ag are the major drivers for the intermetallic layer formation in titanium," he says.

The diffusion bonding process can occur as either a solid-state or a liquid-phase bonding process. Similar pure material bonding has historically been as a solid-state operation. This method simplifies the process from an assembly standpoint, as faying surfaces can be easily matched before placing a charge into the furnace. Alignment pins and tack welding may be used for this process as well. Because no liquid phase is present in diffusion bonding, slight deformation occurs at the surface. This results from applied pressure used to flatten surface asperities and break up residual surface oxides before bonding.

In the liquid-phase diffusion bonding process, an interlayer typically melts at the faying surfaces. In this instance, lower pressure than solid-state diffusion



The concept is to bond layers of sheet metal that contain machined channel/ microchannel structures.

bonding is used, and even less deformation occurs at the surface. Depending on the thermal cycle and composition of the interlayer materials combination and the interlayer selected, an interdiffusion occurs between the interlayer and base materials on either side of the joint through the metallurgical processes known as a eutectic or peritectic phase change.

The thickness of the final intermetallic reaction layer is a result of first from the liquid-phase diffusion and second, from the solid-state diffusion. Bond strength is a function of the intermetallic compounds formed, the thickness of the intermetallic zone, and anomalies, such as voids, at the interface.

EXPLORING DIFFUSION BONDING

There are several ways for a manufacturer to investigate how diffusion bonding of dissimilar metals could benefit their process. Much scientific literature is readily available for specific material combinations and processing times and temperatures depending on the application. For example, Kavian O. Cooke and Anas M. Atieh conducted an exhaustive review published in 2020 titled "Current Trends in Dissimilar Diffusion Bonding of Titanium Alloys to Stainless Steels, Aluminum, and Magnesium Journal of Manufacturing and Materials Processing."

While ample research exists on the subject, design engineers can still find it challenging to convert the information into real-world manufacturing of a specific part. When this is the case, it can be helpful to partner with experts with an extensive database of successful processing parameters from previous applications and access to industrial-scale equipment.

"In most cases, we start talking with the manufacturer about introducing new designs, and consult on possible materials, designs, and also conduct pre-bonding runs as needed," says Palamides. PVA TePla provides support, including specific material combinations, processing times, and temperatures.

He notes that proper design will allow diffusion bonding of assemblies, whether an intimate interface or multiple interfaces that are planar parallel simultaneously. However, surfaces that are not perpendicular to the compressive force of the hydraulic ram will not bond properly.

Palamides says that the manufacturer begins by working with their mechanical, thermal, and modeling teams. Once a design is complete, the next step is to fabricate trial samples that are truthful to the characteristics of the final interface.

"Locate a vendor who can perform contract service trial runs. Propose a test matrix to ensure your schedule is aligned with project goals," says Palamides.

ADVANCES IN DIFFUSION BONDING EQUIPMENT

Despite its benefits, the use of diffusion bonding has been limited by more practical considerations until recently. Specifically, the size limitation of the furnace chamber and limits to the amount and uniformity of the pressure applied across the entire surface area of the part. Run times are also long, often lasting an entire day.

Advances in high vacuum hot presses now allow superior pressure control and rapid cooling systems to improve the bond, increase yields and significantly decrease cycle time.

In the case of the pressure applied, for example, integrated single cylinder hydraulic presses can apply a consistent,

measurable amount of force. However, this provides very little control over large parts with more complex geometries. To improve force distribution, thick graphite pressing plates (10-15 inches in height) mate the metal layers together at a more consistent pressure. Unfortunately, this takes up furnace space while adding to the time to heat the surfaces of the metals.

Today, manufacturers such as PVA TePla offer multi-cylinder systems with large pressing plates that can accommodate various parts. The largest, the company's MOV 853 HP, can process substrates as large as 900mm (35.43") x 1250mm (49.21"), which is quite large for diffusion bonding. The pressing force is 4,000 kN.

By controlling each cylinder independently, the integrated press provides remarkably consistent pressure across the entire surface. The MOV also comes with built-in pressure transducers along the bottom of the pressing plate. The individual hydraulic cylinders can be adjusted in the software to achieve uniformity even over large areas based on the sensor feedback.

"Today's equipment provides detailed measurements of the material properties during bonding," says Palamides. "This valuable feedback can show how the materials are compressing, if it is being crushed, and if a transient liquid layer is forming – and other KPIs of the procedure."

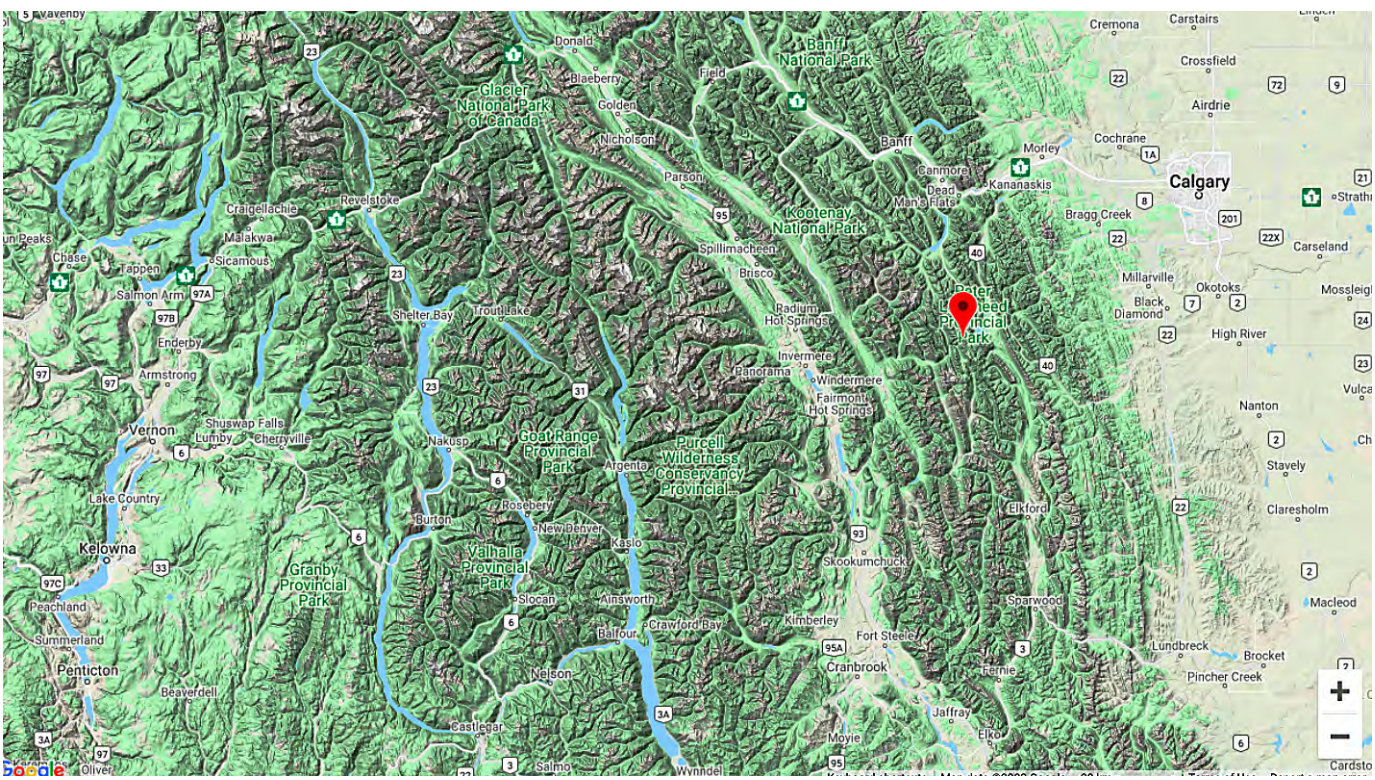
VERIFYING THE INTEGRITY OF THE BONDING INTERFACE

To ensure the quality of the interface, Palamides recommends analyzing samples through non-destructive inspection techniques, such as Scanning Acoustic Microscopy (SAM). Or more costly analysis performed using Scanning Electron Microscopy/Energy Dispersive X-ray Spectroscopy (SEM-EDS). Subsequently, trial samples may be destructively analyzed and fabricated into standard mechanical test specimens to collect repeatable data.

While there is growing interest in diffusion bonding, all applications require thorough research to optimize the joining process. ■

Lost in Space

An incorrect understanding of his multi-function instrument nearly spells disaster for this pilot flying into tricky mountain conditions.



ON **03 JANUARY 2021,** the privately registered Mooney M20F aircraft (registration C-GYGN, serial number 221353) was conducting an instrument flight rules (IFR) flight from Airdrie Aerodrome (CEF4), Alberta, to Nelson Aerodrome (CZNL), British Columbia. The pilot was alone on board. The aircraft departed at 1120 in visual meteorological conditions and initially climbed to 14 000 feet above sea level (ASL). Shortly after levelling off, air traffic control (ATC) asked the pilot if he could maintain an altitude of 15 000 feet ASL for a portion of the flight.

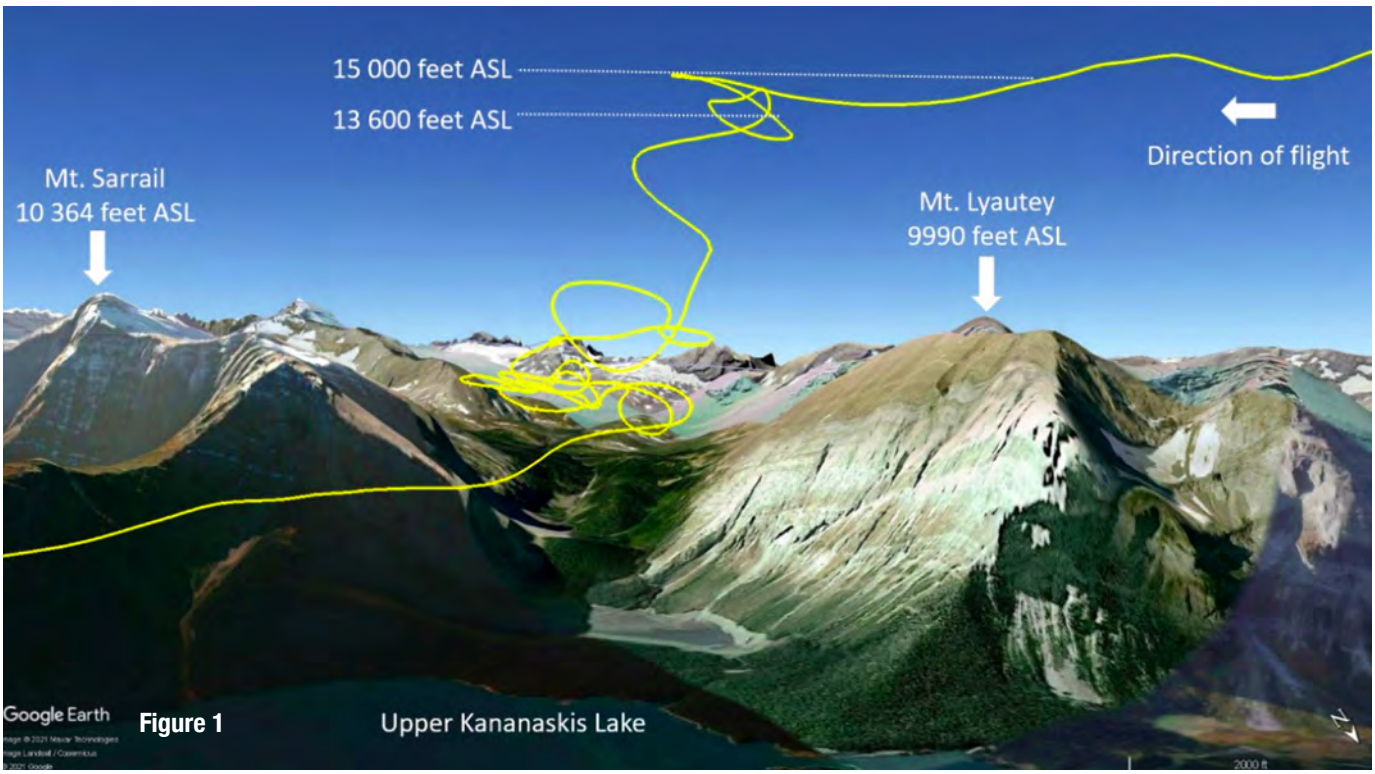


Figure 1

The pilot accepted and climbed the additional 1000 feet, levelling off at 15 000 feet ASL at 1157. The pilot then requested a minor deviation from the route of flight to avoid entering clouds. However, during this deviation, the clouds could not be avoided, and the aircraft entered instrument meteorological conditions (IMC). Shortly thereafter, the aircraft's attitude direction indicator (ADI) displayed the "AHRS ALIGN" (attitude and heading reference system alignment) message, and indications of attitude (pitch and bank) were lost while indications of airspeed, altitude, and vertical speed were retained (See figure 1 above).

At the same time, the aircraft's horizontal situation indicator (HSI) also indicated a failure, displaying a red X over the HDG (heading) annunciation. The pilot attempted to switch the HSI to the ADI page using the instrument's touch screen function and selector knob, but was unsuccessful.

While the aircraft was still flying in IMC, its altitude began to fluctuate. It

Opposite page, top: Map of BC and Alberta showing the location of the occurrence. Opposite page, bottom left: Garmin GI 275 multi-function instrument configured as an attitude direction indicator. Left image demonstrates a functioning attitude direction indicator.

Top of page: (Figure 1) Aircraft's flight path during loss of control event derived from its global positioning system.
Above: Mooney C-GYGN. — Michael G. MacKinnon photo. (JetPhotos)

then began an unintentional left turn, eventually turning approximately 90° to the left of the assigned track. The pilot informed ATC of the instrument malfunction and requested to return to the Calgary, Alberta, area. At 1206, the pilot declared an emergency, reporting the loss of attitude and heading information from the aircraft's instruments. Thirty seconds later, the pilot informed ATC that the aircraft's HSI was functioning again. The pilot had briefly observed an image on the ADI at that time; however, the flight data recorded by the instrument indicate that AHRS data remained unavailable.

ATC provided the pilot with a heading that would turn the aircraft toward Calgary. During this turn, the pilot experienced spatial disorientation, the aircraft's bank angle progressively increased and the aircraft began to descend. Over the next 5 minutes, control of the aircraft was lost multiple times; the aircraft entered a series of spiral dives, abrupt climbs, and at least 2 aerodynamic stalls. Flight data recovered from the ADI and HSI indicate that during these manoeuvres, the aircraft's climb rate increased to as much as 8500 fpm, and its descent rate increased to as much as 23 000 fpm.

> *... the aircraft's airspeed varied from a low of 43 knots indicated airspeed (KIAS) to a high of 242 KIAS, exceeding the aircraft's never exceed speed by approximately 70 knots.*

In addition, the aircraft's airspeed varied from a low of 43 knots indicated airspeed (KIAS) to a high of 242 KIAS, exceeding the aircraft's never exceed speed by approximately 70 knots. The aircraft descended to as low as 8100 feet ASL (approximately 700 feet above ground level [AGL]) before abruptly climbing again.

The pilot was able to see the terrain below as the aircraft descended through approximately 8500 feet ASL and control of the aircraft was regained at approximately 8100 feet ASL. At the time, the aircraft was in the Kananaskis Valley, where nearby mountain peaks extended up to 10 364 feet ASL. Flight visibility at the time was approximately 1 statute mile (SM), and improved to 2–3 SM as the pilot descended to approximately 7500 feet ASL, while flying toward Upper Kananaskis Lake.

The Mooney M20F C-GYGN

COMMUNICATIONS

Because communications and radar depend on line-of-sight, once the aircraft had descended below 13 600 feet ASL, ATC was unable to communicate directly with the pilot or continue tracking the aircraft on the secondary surveillance radar (using the aircraft's transponder). After recovering from the loss of control event, the pilot was able to relay messages to ATC by communicating on the emergency frequency (121.5 MHz) with aircraft flying at higher altitudes.

POST-OCCURRENCE ACTIVITIES

The occurrence pilot entered the avionics defect in the aircraft's journey log and, 1 day after the occurrence, the aircraft owner (who was not the occurrence pilot) flew the aircraft to Red Deer Regional Airport (CYQF), Alberta, to address the defect. Contrary to the regulations, no entry was made in the aircraft's journey log or technical record identifying the exceedance of aircraft limitations. However, the pilot and owner were not aware of the exceedance at this time.

The aircraft continued to be flown, and for an additional 12.3 hours after the occurrence flight, until the flight data retrieved from the Garmin GI 275 multi-function instruments (MFIs) revealed the magnitude of the exceedance. At that time, the aircraft owner also noted fuel weeping from around rivets in several locations and that the landing gear no longer

fully retracted. The aircraft was inspected in accordance with Appendix G of Canadian Aviation Regulations Standard 625, repaired, and returned to service on 02 March 2021.

WEATHER INFORMATION

Before the flight, the pilot received a weather briefing for the route of flight from NAV CANADA. The pilot was informed that there was the potential for very low cloud throughout the mountain valleys, but that it would likely begin to dissipate during the flight. The graphic area forecast issued on 03 January 2021 at 1026 and valid at 1100, indicated the following for a significant portion of the aircraft's route over the Rocky Mountains: broken clouds based at 7000–9000 feet ASL, with tops at 12 000 feet ASL, and visibility greater than 6 SM; and occasional altocumulus castellanus clouds up to 18 000 feet ASL, with visibilities ranging from 2 SM to greater than 6 SM in light rain showers or light snow showers and mist; and patchy ceilings from 500 feet AGL to 1500 feet AGL.

AIRCRAFT INFORMATION

The Mooney M20F aircraft is a single-engine, 4-seat, low-wing aircraft equipped with retractable landing gear. The occurrence aircraft was manufactured in 1976. Records indicate it was certified, equipped, and maintained in accordance with existing regulations.

At the time of the occurrence, the aircraft had accumulated approximately 2206.5 total airframe hours.

The aircraft was not equipped with a flight data recorder or a cockpit voice recorder, nor was it required to be by regulation. However, the aircraft's Garmin GI 275 MFIs recorded many flight data parameters pertaining to the occurrence flight. The aircraft was not equipped with an autopilot.The aircraft was equipped with a Sky Ox portable oxygen system connected to 4 nasal cannulas. The pilot was using the system during the occurrence flight, and was wearing a portable pulse oximeter.

GARMIN GI 275 MULTI-FUNCTION INSTRUMENT

The Garmin GI 275 MFI is an electric, solid state, highly configurable upgrade for many traditional round-gauge instruments, such as ADIs and HSIs, which contain mechanically driven gyros traditionally powered by a vacuum-driven engine pump. It can be configured as either a primary or a standby instrument.

When a standby ADI or HSI detects a fault from a compat-

ible interconnected unit, it will automatically switch to reversionary operation mode, which means it "exclusively behaves as a Primary ADI unit until the fault is resolved." This mode can also be manually selected from a panel-mounted switch. When a unit is configured as a primary HSI and a fault occurs with an interconnected unit, it will not automatically switch to reversionary operation mode. In addition, the pilot cannot manually select the ADI display page because it is not one of the pages available when the unit is configured as a primary HSI. Pages available for a primary HSI configuration are HSI and HSI Map; pages available for standby ADI and standby HSI include an ADI page.

In July 2020, the occurrence aircraft's directional gyro was removed and a Garmin GI 275 MFI was installed in accordance with U.S. Federal Aviation Administration Supplemental Type Certificate (STC) SA02658SE. This MFI was configured as a primary HSI. In October 2020, the aircraft's attitude indicator was removed and a second Garmin GI 275 MFI was installed in accordance with the same STC, but was configured as a primary ADI. Because both of these instruments were configured as primary units, a reversionary switch was not installed, nor was it required to be.

The aircraft's owner and the occurrence pilot both thought that if a fault was detected in the ADI, the HSI would either automatically enter the reversionary operation mode and display the ADI page, or the pilot would be able to select the ADI page manually. Therefore, their understanding of both the system's automation and the units' reversionary capabilities was incorrect.

The investigation attempted to determine more precisely the source of the initial fault. However, no supplemental information about the instrument, possible reasons it would require realignment while the aircraft was in flight, or analysis of the occurrence aircraft's recorded fault logs were provided to the investigation by Garmin. Therefore, the exact source of the initial fault could not be determined. Nevertheless, based on the information that was available to the investigation, it was determined that the most likely cause of the AHRS ALIGN message on the primary ADI was either an uncommanded AHRS alignment that took place during the flight or a sensor fault within the AHRS that required the instrument to be realigned once the fault was resolved.

The AHRS can align itself while the aircraft is taxiing or when it is in flight; the realignment takes 1 to 2 minutes. When the AHRS ALIGN message is displayed, control of the aircraft must be maintained within ±10° bank, ±5° pitch, and at a speed of 200 knots or less in order to successfully complete the realignment; exceeding these parameters may delay or pre-

Event Reminders

HAI HELI-EXPO 2022

THERE WILL BE something for everyone at HAI HELI-EXPO 2022, March 7–10 (exhibits open March 8–10), from networking opportunities with thousands of aviation professionals from around the world to fly-ins and fly-outs featuring the biggest names in the rotorcraft industry to more than 100 helicopter-focused educational opportunities. After a year of virtual events, HAI HELI-EXPO 2022 will be your chance to resume business as usual. The Expo show floor is famous for hosting everything you need for your helicopter business, hosting 50-plus aircraft on the show floor as well as hundreds of exhibitors.

Aéro Montréal
International Aerospace Week
April 4-7, 2022 www.aeromontreal.ca

Aéro Montréal, Québec's aerospace cluster, is kicking off International Aerospace Week - Montréal 2022 in collaboration with the National Research Council of Canada (NRC) and the Palais des Congrès de Montréal. From April 4 to 7, 2022, Aéro Montréal will bring together all the players in the Québec, Canadian and international aerospace industry for a hybrid event (in-person and virtual).

The event will offer an innovative experience at the heart of the industry's new realities: the week will begin with the eighth edition of the International Aerospace Innovation Forum, on April 4-5, on the theme "Journey to the heart of sustainable air mobility." It will continue with a day dedicated to defence and security and space activities. Then on April 7, with Aéroportail: Vitrines 2022, the event is dedicated to promoting the aerospace industry's initiatives to its future generation of talent. ✪

vent the AHRS from realigning. This information is contained in the Garmin GI 275 Pilot's Guide, as well as the emergency procedures in the Garmin Airplane Flight Manual Supplement (AFMS). Although the pilot did have access to these documents during the occurrence flight, he did not refer to them as he was focussed on controlling the aircraft. Further, the aircraft's cockpit checklists had not been amended with the additional normal and emergency procedures contained in the AFMS.

PILOT INFORMATION

The pilot held an airline transport pilot licence – aeroplane, and a valid Category 1 medical certificate. He had accumulated over 6000 hours total flight time, including 21 hours in the 7 days before the occurrence. The pilot had 29.4 hours total flight time on Mooney M20 aircraft. Of those, 2.9 hours were on the occurrence aircraft in the same configuration as on the occurrence flight.

The Garmin AFMS indicates that the Garmin GI 275 MFI "system requires a reasonable degree of familiarity to avoid becoming engrossed at the expense of basic instrument flying in IMC […]" and "[p]ilot workload will be higher for pilots who are not familiar with the GI 275s or GI 275 system in an IFR environment […]".

The manual recommends that pilots use the Garmin GI 275 Pilot's Guide and a tablet trainer app to increase their familiarity with the instrument. The investigation was unable to find the trainer app and it was not provided to the investigation by Garmin. The occurrence pilot did not know about the app.

In June 2020, the pilot completed recurrent training and successfully completed a pilot proficiency check (PPC) for a business jet, thereby satisfying the requirement to exercise the privileges of an instrument rating. The occurrence pilot's training included recovery from unusual altitudes (often referred to as upset recovery training) and abnormal procedures for avionics systems. However, PPCs do not evaluate a pilot's ability to recognize the onset of, or recover from, unusual altitudes.

By contrast, pilots who complete an instrument proficiency check (IPC) to satisfy the requirements of an instrument rating must demonstrate their ability to recover from unusual altitudes twice.

SAFETY MESSAGES

Regardless of experience level or rating, it is important that pilots acquire and maintain the knowledge necessary to safely operate each aircraft they fly. This includes seeking qualified instruction to learn and recognize the features, failure modes, and limitations of aircraft equipment before conducting a flight, particularly when IMC may be encountered.

In the event of an instrument failure in IMC, pilots who do not have recent partial panel flight experience may become spatially disoriented and lose flight control. ■

(These were excerpts from Transportation Safety Board of Canada's investigation into this occurrence. The Board authorized the release of its report on 30 June 2021. It was officially released on 13 July 2021.)

Aviation Services

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High Hopes

The plan here is to create the world's highest Wi-Fi hotspot.

THE PARIS-BASED TECH FIRM THALES says it plans to fly a zero-emission glider to more than twice the altitude of a commercial airline flight where it will establish the world's highest W-Fi hotspot under the umbrella of Thales' mobile satellite communications system, FlytLink.

In this effort, Thales will partner with Airbus Perlan Mission II, an international climate and aerospace research project, and through this collaboration the world will get a live, front row view of the stratosphere and hear from glider pilots as they soar to the edge of space.

Nevada-based Airbus Perlan Mission II has already set aviation world altitude records in the experimental Perlan 2 glider, which was designed to fly to 90,000 feet without an engine. Originally launched in 2015, the Perlan 2 achieved its highest record-setting flight of above 76,000 feet in 2018. The organization's mission is to conduct climate, atmospheric and aeronautical research at extreme high altitudes. Applications of their research include informing more accurate climate-change models, innovating fuel-efficient or zero-emission aviation, and even demonstrating the feasibility of using energy-efficient winged aircraft on Mars.

Soaring too high to use ground-based communications, the Perlan 2 glider will be fitted with the FlytLink Thales Iridium Certus based satellite communications system. This means that for the first time it will be possible to make a live feed available to STEM students, researchers and aviation enthusiasts around the world while the aircraft is in flight, enabling access to real-time data downloads.

FlytLink is the latest generation of Iridium-based satellite communications systems for cockpit and crew operations. Anywhere in the world, whether flying over the poles, the ocean or land, FlytLink offers coverage and connectivity for critical operations. Its resilience, high dependability and low size, weight and power make it adaptable to any aircraft, including gliders such as Perlan.

When Perlan 2 reaches its next record-breaking target altitude of over 90,000 feet, it will be the highest a winged aircraft has ever flown in level flight. Equipped with cutting edge aviation technology and using spacecraft engineering, its glider wings can fly in less than three percent of normal air density at temperatures of -70C approximating conditions on Mars.

Designed to support a wide range of use cases in maritime, land mobile and aviation markets, Thales Iridium Certus based satcom solutions are already used widely among vessels and land/mobile applications to keep critical communications when it is needed at all times, anywhere on the planet. ■

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