

**NATIONAL TRANSPORTATION SAFETY BOARD
OFFICE OF AVIATION SAFETY
WASHINGTON, D.C. 20594**

July 26, 2021

POWERPLANTS GROUP CHAIRMAN'S FACTUAL REPORT

NTSB ID No.: CEN19LA295

A. ACCIDENT

Location: Olney, Texas
Date: August 29, 2019
Time: 1100 central daylight time
Aircraft: Air Tractor AT-502A, Registration: N8517Q

B. POWERPLANTS GROUP

Investigator-In-Charge: Todd Fox
National Transportation Safety Board
Chicago, Illinois

Powerplant Group Chairman: Harald Reichel
National Transportation Safety Board
Washington, DC

Member: Dakota Lowe
Air Tractor, Inc.
Onley, Texas

Member: Les Doud
Hartzell Propeller
Picqua, Ohio

C. SUMMARY

On August 29, 2019, about 1100 central daylight time, an Air Tractor AT-502A airplane, N8517Q, collided with terrain during a forced landing shortly after takeoff from Olney Municipal Airport (ONY), Olney, Texas. The commercial pilot sustained minor injuries, and the airplane was substantially damaged. The airplane was registered to and operated by Lane Aviation as a Title 14 Code of Federal Regulations (CFR) Part 91 business flight. Day visual meteorological conditions prevailed, and no flight plan was filed for the flight that had the intended destination of Lane Airpark (T54), Rosenberg, Texas. The pilot reported that the purpose of the flight was to fly the airplane from the Air Tractor factory to his company's base at Lane Airpark.

According to Air Tractor documentation, the airplane had accumulated about 1 hour of flight time before it received its airworthiness certificate on August 26, 2019. The airplane had been previously topped-off with fuel (234 gallons), and fuel samples obtained during the pilot's preflight inspection were free of water and particulate. The pilot noted that the airplane was equipped with a ferry tank fuel modification; however, the ferry tank (hopper) did not contain any fuel.

According to the Federal Aviation Administration (FAA), who along with Air Tractor engineers, interviewed the pilot after the event, the pilot reported that the engine started normally and that he did not observe any anomalies on the engine gauges. The pilot stated that he completed a brake check and cycled the propeller 3 times while taxiing to runway 17. The pilot noted that he did not operate the engine on the ferry tank because it was empty, and that the taxi and takeoff were performed with the fuel selector positioned to the main fuel tank. The pilot stated that after he taxied onto runway 17, he locked the tailwheel and increased engine power to 1,500 foot-pounds (ft-lbs.) of torque as he held the brakes. The pilot increased engine power to 2,200-2,300 ft-lbs. of torque during the takeoff roll and achieved a normal liftoff at 95-100 knots. The pilot reported that he maintained a higher-than normal climb angle to quickly ascend to a safe altitude above the runway; however, at 200 ft above ground level (agl) the engine power began to surge between idle and full power at approximately 1.5 second intervals. He described the sensation as alternating between being pushed back into the seat and being thrown forward until the seat belt restrained any further motion.

The pilot reported that he did not believe there was adequate runway remaining to ensure a safe landing, so he entered a left turn to land on runway 31. The pilot stated that during the turn he saw an amber annunciator panel light illuminated, which he believed to be the fuel filter warning light. The pilot stated that he was unable to complete the turn to runway 31 without entering an aerodynamic stall, so he leveled the wings and made a forced landing in a hay field to the southeast of runway 31. The pilot reported that the airplane landed hard on the left main landing gear before it collided with a tree stump. The airplane then swerved to the left and down into a ditch.

With the approval of the National Transportation Safety Board (NTSB) Investigator-In-Charge (IIC), an initial on-scene wreckage examination was conducted by

two Air Tractor representatives and one from Pratt & Whitney Canada under the cognizance of an FAA investigator and a report was written. The airplane was subsequently recovered, moved from the accident scene and stored at the Air Tractor ‘Olney Savings’ hangar, in Olney, Texas, until the powerplant examination occurred on November 6-8, 2019, at which time, it was transferred to the Air Tractor production hangar for the examination.

The engine controls consisting of the Propeller Governor also referred to as a constant speed unit (CSU), FCU, and the engine mounted high-pressure fuel pump were tested. The airframe supplied fuel hoses, low-pressure electric and mechanical pumps were tested. No pre-accident faults were found in any accessory or component that would have precluded normal operation.

A review of the surge frequency indicated that the surge was caused by a high frequency cycle behavior of the propeller blades rather than an engine power fluctuation. No pre-accident faults were found during the teardown and examination of the propeller that would have precluded normal operation.

The airframe fuel components which included the fuel hoses, electric boost pump, and engine driven mechanical boost pump were tested, and no pre-accident faults were found in any accessory or component that would have precluded normal operation.

A review of the Air Tractor propeller cycling procedure was reviewed with Air Tractor, where it was noted that the cycle was from fine pitch to feather. A deeper cycle of reverse to feather was possible but its impact on purging more air from the propeller piston could not be determined.

Air trapped in the propeller piston was considered a possible cause of the event. The propeller installation and possibility of air leakage into the propeller cavity was reviewed.

D. DETAILS OF INVESTIGATION

D.1 Powerplant Information

D.1.1 Engine Description

The engine (See [Figure 1](#)) was a Pratt & Whitney Canada PT6A-140AG which produces a takeoff power of 867 horsepower. The PT6A engine is a 2-spool turbo-shaft engine. The power section module consists of single stage power turbines (PT), which drive the propeller through a 2-stage planetary reduction gearbox (RGB). The gas generator (GG) module consists of a compressor section, which has 3 axial, and 1 centrifugal stages driven by a single turbine. The combustion chamber is a reverse-flow annular type. The constant-speed, variable pitch propeller is a single-acting type and is hydraulically controlled. The accessories are mounted on the accessory gearbox (AGB).

The engine power management system consists of a hydromechanical FCU, which governs the gas generator speed by delivering fuel flow to the engine in response to the power lever angle, compressor discharge pressure and GG speed and a propeller governor or constant speed unit (CSU) and overspeed (O/S) governor which provide protection against propeller and PT overspeed.

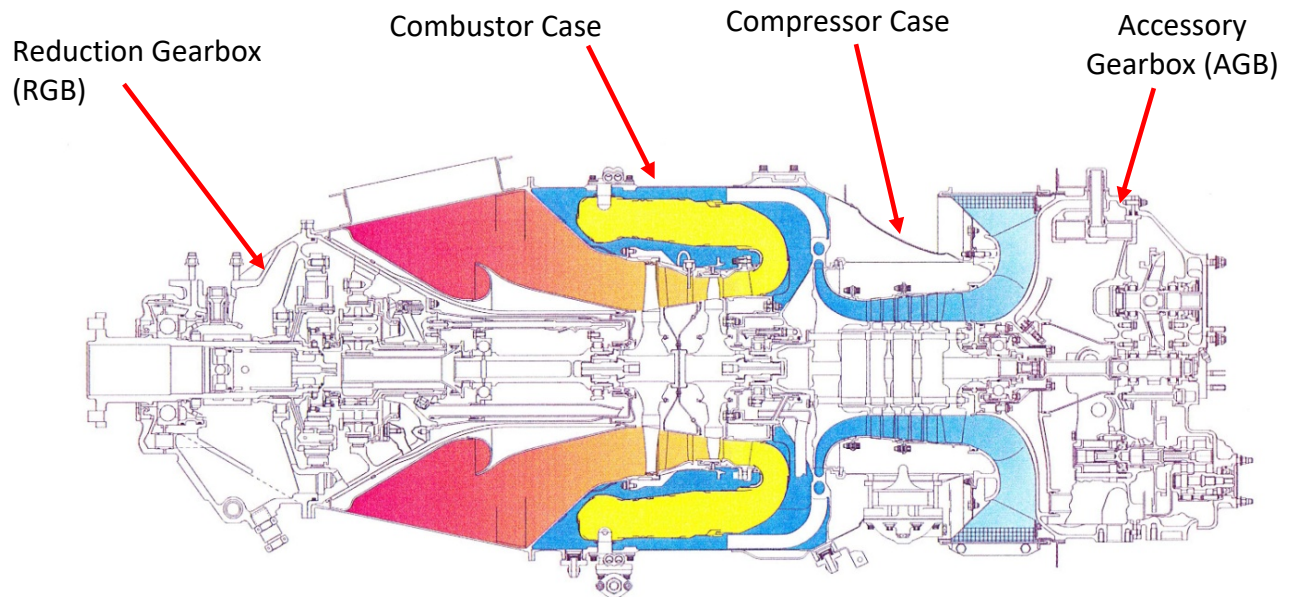


Figure 1 – Pratt & Whitney Canada PT6A-60 Cross Section (Figure Courtesy of Pratt & Whitney Canada)

D.1.2 Engine History

The accident engine was a newly manufactured PT6A-140AG, serial number (S/N) PCE-VB0070 and had been installed into the new airplane. According to the Air Tractor, the engine times were as follows:

Total Time Since New (TTSN):	1 hour
Cycles Since New (CSN):	less than 10 cycles
Time Since Overhaul (TSO):	not applicable
Hours Since Hot Section Inspection (HSI):	not applicable
Cycles since HSI:	not applicable

The airframe did not have an electronic engine monitoring recorder installed.

D.1.3 Propeller Description

The 4-bladed Hartzell propeller (Figure 2) is a 108" diameter, single-acting, hydraulically operated, constant speed model with feathering and reversing capabilities. The blades are of aluminum construction. The hub and blade clamps are steel. Propeller rotation is clockwise as viewed from the rear. Oil pressure from the propeller governor is used to move the blades to the low pitch (blade angle) direction. Blade-mounted counterweights and feathering springs actuate the blades towards the high pitch (feather) direction in the absence of governor oil pressure. The propeller incorporates four beta guide rods and a feedback ring that allows the propeller governor to control the blade angles below the flight idle position in ground operations only. The beta guide rods slide through phenolic guide collar bushings.

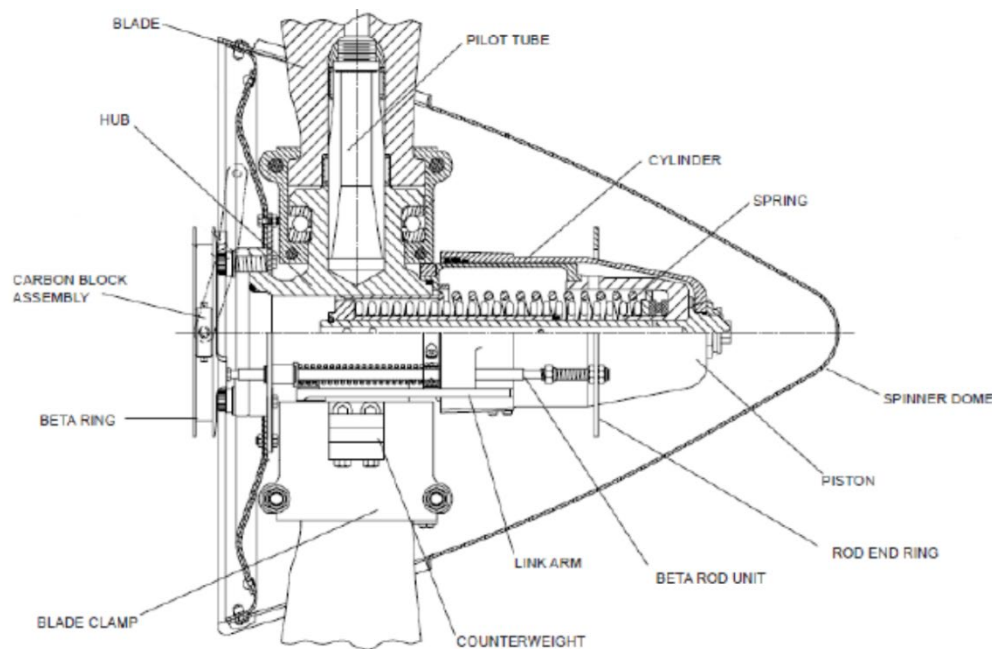


Figure 2 – Propeller Cross Section (Figure Courtesy of Hartzell)

According to the Hartzell Installation Data Sheet No. 3340 and Aircraft type certification data sheet (TCDS) A17SW, the propeller settings adjusted during manufacturing are:

(Angles are referenced at the 42-inch radius)

Reverse:	-15.0 + 0.5 degrees
Low Pitch/Beta Pick-Up:	+8.2 + 0.1 degrees
Feather:	+80.7 + 0.5 degrees
Counterweight:	Positive

The AT502 power management system does not incorporate an auto-feather or a reverse lock-out feature.

D.1.4 Propeller History

The 4-bladed Hartzell propeller on the engine was model number HC-B4TN-3C with T10702NS blades, serial S/N CDA5796 and it was manufactured in March 2019. There had not been any service on the propeller since manufacture.

	Serial Number	Manufacture Date	TTSN (hrs.)	TSO (hrs.)
Hub	D8474A	3/8/2019	1	N/A
Blade No. 1	L95795	3/6/2019	1	N/A
Blade No. 2	L95790	3/6/2019	1	N/A
Blade No. 3	L95794	3/6/2019	1	N/A
Blade No. 4	L94250	12/7/2018	1	N/A

Table 1 – Propeller Data

D.2 Details of the Field Examination

D.2.1 General External Condition & Observations

The airframe and engine were recovered from the accident site on August 30, 2019 and placed in the ‘Olney Savings’ hangar, part of the Air Tractor facility in Olney, Texas. Because of its remote location, it was moved into the Air Tractor facility production hangar on November 6, 2019 for the powerplant examination.

The wings were heavily damaged at the end of both tips with the outboard 5 feet of wing crumpled and fractured ([Photo 1](#)). Clumps of grass were still stuck in the fracture cracks of the skin. The aft approximately 10-foot section of the empennage was fractured and separate from the fuselage. The landing gear was buckled near the upper bend and the internal fuselage structure was buckled near the wing root. The cockpit was generally intact. The engine mount structure was bent upwards by approximately 2.5 feet and aft-wards approximately 1.5 feet ([Photo 2](#)).

The engine was still attached to the airframe engine mount ring ([Photo 3](#)); however, the elastomeric mounts and attachment bolts were deformed. The propeller was separated from the engine propeller shaft. The 5-inch section of the propeller shaft flange was fractured and two propeller mounting bolts were still present in the flange holes ([Photo 4](#)). The starter generator was undamaged and still attached to the AGB.

D.2.2 Engine

All the major engine modules were bent and/or fractured (Photo 5). The RGB was fractured circumferentially through 360 degrees (Photo 6). The exhaust housing was bent approximately 20 degrees upward and buckled. The combustor housing (Photo 7) was buckled at the upper flanges in the main mount plane and deformed into the housing. The external compressor housing was buckled, and the inner panels were deformed and fractured. The AGB was undamaged but slightly askew from the engine centerline.

The propeller shaft could not be turned. The PT blades were examined through the exhaust case and all were found to be intact and undamaged; however, they were locked against the deformed outer shroud, preventing them from rotating. The RGB housing was fractured and not disassembled further. The RGB chip detector was clean.

The splined accessory output shafts in the AGB could not be turned. The 1st stage compressor blades were examined through the main engine air inlet and were all found to be intact and undamaged; however, they were locked against the deformed outer shroud, preventing them from rotating. The AGB was not disassembled further.

The oil level in the sight glass was observed to be at the normal level, and the oil was clean. The oil filter was removed, revealing a clean, oil wetted filter element.

The FCU control cable from the cockpit control to the FCU input lever was continuous; however, the cable was deformed, preventing movement. The prop reversing cambox was present; however, the beta cam was fractured. The beta push-pull cable from the cambox to the propeller governor was continuous; however, it was deformed, preventing movement.

The propeller control cable from the cockpit control to the speeder spring lever was continuous; however, the cable was deformed, preventing movement.

The FCU, part number (P/N) 3076428-03, S/N 21680452 (Photo 8) was intact and internally fuel wetted; however, the input power lever shaft was bent and could not be rotated. The input drive spline was undamaged and could be rotated with normal effort. The high-pressure fuel pump (HPFP), an Argo-Tech P/N 3040760D, S/N 016857 (Photo 9) was intact, fuel wetted and undamaged. The fuel pump was removed with normal effort, revealing an undamaged AGB input splined coupling. The FCU and HPFP were sent to the Pratt & Whitney (P&W) Canada overhaul facility in St. Hubert, Quebec, Canada, where they were tested and found to be operating within normal parameters. A further teardown of the HPFP revealed no pre-accident damage that would have prevented normal operation.

The CSU, P/N 3074154-01, S/N 21633198 housing was fractured, revealing the speeder spring and cam assembly (Photo 10). The beta valve was free to move. The beta valve lever was in location and still attached to the beta valve, the reversing cam push-pull cable and the carbon block. The carbon block, which was undamaged, was no longer

retained in the beta ring because the propeller was separated from the propeller shaft. The CSU was sent to the P&W Canada overhaul facility in St. Hubert, Quebec, Canada, where it was torn down, revealing no pre-accident damage that would have prevented normal operation.

The fuel to oil heat exchanger (FOHE) P/N 3057249-01 and S/N WA59429 was intact and undamaged. It was retained and sent to the P&W Canada overhaul facility in St. Hubert, Quebec, Canada, where it was tested and found to be operating within normal parameters.

The P3 tube¹ was deformed; however, the four end fittings on the FCU, P3 filter and propeller governor were tight, with lockwire still present. The P3 filter bowl was not tight; however, it was reported that the P3 filter had been inspected shortly after the accident and not tightened again. The P3 filter and bowl were clean.

The overspeed governor P/N 66503-210960-01, S/N 21873526 was undamaged. The gasket and strainer assembly were intact and clean. It was not further examined.

No pre-accident faults could be found in the engine control accessories that would have precluded normal operation.

¹ The FCU determines the engine N1 power condition by sensing the air pressure from the P3 stages of the compressor, and meters the correct amount of fuel to the engine for that condition. If a P3 sense line has a large air leak or is broken, then the FCU will reduce the fuel flow to the idle flow rate.

D.2.3 Airframe Fuel System

Because the pilot stated that he saw an amber warning light during the event that may have been the fuel pressure warning light, the airframe fuel delivery system was further examined.

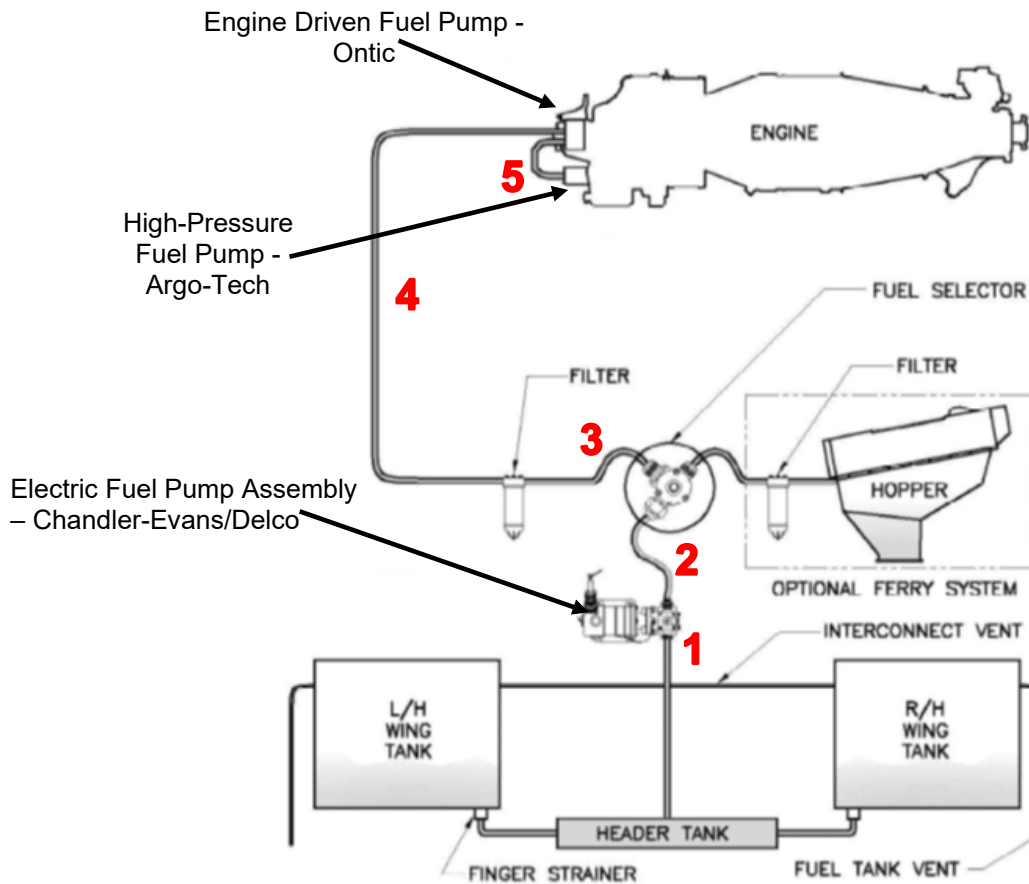


Figure 3 – AT502 Fuel System Schematic (Figure Courtesy of Air Tractor)

The airframe fuel system schematic is depicted on Figure 3. The airplane had the optional ferry fuel system installed; however, according to the pilot, the hopper was not filled with fuel and the fuel selector switch was always in the normal header tank draw mode during the event flight. The hopper section and hoses were not examined.

According to Air Tractor, the wing tank finger strainers were examined with FAA oversight and found to be clean.

The five flexible fuel lines (numbered on Figure 3) were removed and examined with a borescope. Line 4 passes through a firewall and is comprised of two separable hoses. All hoses except for number 2 were internally clean and unobstructed.

Examination of hose number 2, a Parker Stratoflex 111-12, MIL-DTL-8794-12 3Q18 OELG7 hose incorporated into an Air Tractor part number 51097-26 (05-30-2019), revealed an internal fracture in the rubber sleeve at approximately 20 inches from the fuel pump fitting ([Photo 11](#)). When examining the 30-inch-long hose location in the airframe, it was noted that the hose is in a looped condition when installed and that it is supported with a small tie-wrap against a small diameter structural airframe strut at the 20-inch location. It was additionally noted that the airframe strut was buckled near the tie-wrap location during the accident and may have contributed to the internal hose fracture. The hose was sent to Parker-Hannifin, the manufacturer, for further examination. It was determined that the internal tearing of the rubber was the result of a sharp bend that exceeded the minimum bend radius limit of the hose, consistent with having occurred after the initial impact.

The low-pressure airframe electric fuel pump ([Photo 12](#)) is an assembly made by Sun-Air Parts and consists of a Chandler-Evans P/N CE9135, S/N E119888 pump and a Delco motor P/N A4949, S/N 27347. It was tested at the Sun-Air facilities in Valencia, CA, revealing a unit that was slightly out of calibration, but with no pre-existing mechanical or electrical damage. According to Air Tractor, the airframe electric fuel pump assembly is powered only during engine starting sequence, after which it is shut down, requiring only the engine driven pump (EDP) P/N 51076-7, S/N 01033 to supply low pressure fuel to the engine HP fuel pump. The EDP is an Air Tractor supplied component that is attached to the engine AGB and is about 4 feet above the fuel header tank, so the fuel supply hoses are always operating under a negative pressure. The EDP ([Photo 13](#)) was tested at the manufacturer's, Ontic facility in Chatsworth, CA. Despite the minor pressure variation and minor scoring observed in the rotor elements, no pre-existing damage was found in the mechanical fuel pump that would have precluded normal operation.

The fuel flow transmitter, a Shadin Avionics P/N 660534S Revision F, S/N 2920 is in the fuel line between the fuel control and the fuel nozzle flow divider. It was removed and examined, revealing a free spinning turbine and an unobstructed tube. It was not further examined.

No pre-accident faults in the airframe fuel system that would have precluded normal operation. No fault was found that could explain a clogged fuel filter amber warning light that the pilot stated he witnessed.

D.2.4 Propeller Teardown

The propeller, a Hartzell P/N HC-B4TN-3C/T10702NS, S/N CDA5796 was intact; however, the spinner was impact damaged, torn, and crushed with counterweight impact punctures. The pitch change mechanism was intact, and no blades could be rotated by hand. The piston was removed, and the measurement of the internal impact crease ([Photo 14](#)) of the cylinder was 1.7 inches from the bottom edge, consistent with the propeller operating in the flight idle range at impact.

All four blades remained attached via the retention clamps, no pilot tubes were fractured and there were no blade fractures. All four blades exhibited aft bending, bending in the direction opposite rotation, and twisting towards low pitch in varying degrees. The four blades indicated a clear progressive bending and twisting in the sequence of rotation ([Photo 15](#)). All four blades exhibited chordwise/rotational abrasion predominantly on the camber side. Blades 1, 2, and 3 had leading edge gouges with material deformation towards low pitch. Blade 2 had a blade arm-to-blade butt signature in the low pitch range of operation. No manufacturing faults were found in the piston and cylinder or the piston ring. All the crank link bearings on the propeller blades and the links and piston were undamaged. All the propeller blade bearings were undamaged.

The investigation considered the impact of a sticky beta guide lug bushings ([Photo 16](#)) and their possible role in the erratic propeller behavior. The beta guide lug bushings were measured and found to be 0.0025 inches below the manufacturer's specification; however, according to Hartzell, it was unlikely that this would have affected the sliding performance of the beta rods. The inner diameters of the beta guide lug bushings were measured and found to be 0.001 inches below the manufacturer's specification; however, according to Hartzell, it was unlikely that this would have significantly affected the sliding performance of the beta rods. The sliding operation of the beta rods could not be tested because the beta rods were deformed during the accident. Swelling, caused by a chemical attack on the phenolic material of the beta guide lug bushings, causing sticking of the beta rod guides was not considered a contributing factor, since the propeller was new and not exposed to rain or crop-dusting chemicals. Additionally, after performing considerable lab tests, Hartzell stated that the guide lug bushings inner diameter is not affected by contact with turbine oil.

No faults could be found within the propeller that would have precluded normal operation. A more detailed report was issued by Hartzell ([see Appendix I](#)).

D.2.5 Propeller Surge

D.2.5.1 Power Surge Phenomenon

The pilot described the surge event as a violent occurrence. He stated that he was pitched forward, so that his seat belt restrained him, and then about a second later, he was thrown to the back of his seat. The cycle continued despite him retarding the power lever in an unsuccessful effort to modulate the power on-off surge.

Although the behavior appears to suggest that the engine power (gas generator section) is cycling between maximum and minimum power, this is not the case because the engine acceleration and deceleration respond in a much slower manner. The maximum acceleration of the gas generator from idle to maximum power is approximately 4-5 seconds. The deceleration is faster but is still about 2-3 seconds. Thus, a full engine output cycle is approximately 7 seconds, which is much slower than what the pilot reportedly experienced. The quick behavior could be explained by a propeller in which the blades change pitch quickly. A recent artificially induced surge test performed on a similar airplane at Air Tractor revealed a cycling time of about 1.2 seconds, similar to what the event pilot encountered (See [Figure 4](#)).

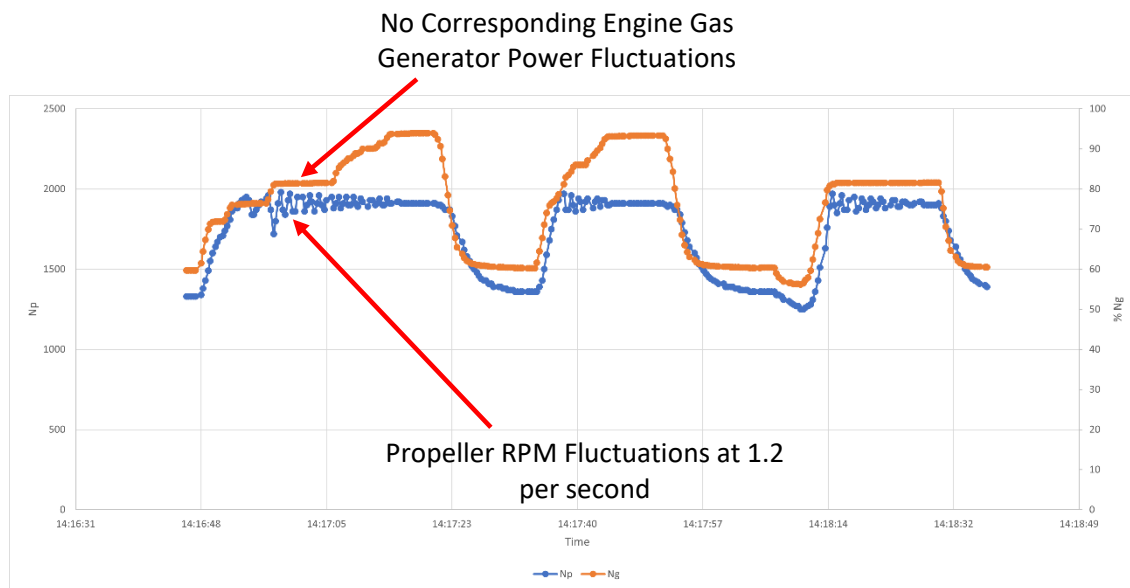


Figure 4 – Graph of Propeller rotational speed (revolutions per minute (RPM)) vs. Time on Test Airplane (Figure Courtesy of Hartzell)

The speed of the propeller is limited to either a pilot-selected lower speed or the maximum set speed set by the propeller governor (CSU) of 100%. In the event of a CSU failure, the overspeed governor serves as an emergency safety device and limits the maximum speed of the propeller to approximately 106% of the maximum propeller governor control speed. The possibility of a propeller governor and overspeed governor interference during maximum speed overshoot during acceleration was initially

considered; however, it was eliminated because the speed of the propeller during surge events does not exceed the propeller governor maximum setting.

A review of the pilots operating handbook (POH) revealed that there is no guidance in the operating handbook that addresses this propeller surge behavior, how to avoid it, or how to respond when it occurs.

D.2.5.2 Interviews with Air Tractor Test Pilots

The chief test pilot stated that when he started work at Air Tractor approximately 20 years ago, the former chief Air Tractor pilot made him aware of a known phenomenon termed ‘propeller surge’ in some AT airplanes. Early AT airplanes were powered with ‘small’ Pratt & Whitney Canada PT6 (PT6-15AG, -27AG, -34AG powered) engines which featured 2200 RPM gearboxes. He further stated that during his Air Tractor employment, he has test-flown about half of the approximately 150 annual production of airplanes for about 20 years, representing between 1000 and 1500 airplanes. Approximately half of all airplanes he has flown were small PT6 powered while the other half were large PT6 (-60 series) powered airplanes. Asked about the frequency of surges during first flight within this group, his approximation was 1 out of 15 have encountered surge. Propeller surge occurred on these engines occasionally; however, he could not ascertain a clear pattern between airplanes that demonstrate surge and those which didn’t.

In the subsequent years, Air Tractor designed and produced larger airplanes that featured higher power engines with different speed reduction (propeller) gearboxes. Generally:

Small engine airplanes - PT6A-15AG, 34AG -	2200 RPM gearbox/prop
Medium engine - PT6A-140 (like AT502) -	1900 RPM gearbox/prop
Large engine - PT6A-60 series -	1700 RPM gearbox/prop

The Air Tractor test pilots stated that almost all propeller surges occur on the small engine series; however, on rare occasions surges have occurred on all model airplanes.

When a surge occurred, he was specifically instructed to NOT change the engine power lever setting, but rather retard the propeller speed lever. He was trained to move the propeller lever very slightly to a lower RPM to stop the surge. The slight (less than ¼ inch) movement on the propeller speed lever needs only to change the propeller speed by 10 or 20 RPM to be sufficient to stop the surge according to the Air Tractor test pilots.

He further stated that all company pilots were trained to cycle the propeller multiple times (4 to 5 times) during initial flight ground operations and that they perform propeller cycles on all new airplanes. Full propeller cycles during ground operations are made by increasing the prop RPM to maximum (2200, 1900 or 1700 RPM depending on the engine model) and then use the propeller control lever to select feather. It was noted

that the propeller is not cycled through the reverse position during the cycling process. The airplane flight manual (AFM) guidance in section 4.2.8 Before Takeoff states to feather twice before takeoff.

Both test pilots stated that they have observed a higher frequency of surges in airplanes that have been stationary for a month or longer. They are not certain of the cause of this phenomena; however, it is believed that over several weeks' time, oil can drain from the propeller dome, allowing the entrance of air. They make sure that all long-standing airplane propellers are given multiple propeller cycles before takeoff. Not cycling the propellers will almost certainly induce a surge situation; however, despite the process, they are still occasionally surge.

The pilots have heard two explanations for the reason these techniques partially work; however, they were only historically developed and have had no testing or substantiation: The first is that the cycling process introduces hot oil into the propeller, thereby 'freeing' the internal propeller mechanisms and allowing it to respond quicker to changes in oil control pressure. The second is the purging of air in the propeller cavity.

Until about 2 years ago all airplanes had their engines motored while still in production, before they were transferred to the flight line. Motoring the engine consists of energizing the starter for about 20 to 30 seconds, which allows the gas generator to reach motoring speed of 10 to 15 percent. This is sufficient to turn the power turbine and propeller shaft and will allow oil to circulate through the propeller control system. No fuel is added to the engine during motoring. It is uncertain if a short motoring cycle is sufficient to fill the propeller nose cavity with oil. The motoring time limitation is due to the heat buildup in the starter/generator. During the last two years, airplane engines have not been motored in the production line and the first engine motor and start is accomplished on the flight line. It is believed that the change was made for safety reasons. The Air Tractor pilots has not noticed any changes in the frequency of surges before and after this process change.

D.2.5.3 Consideration of Air Trapped in Propeller Piston Cavity

Air trapped in the propeller cavity can act as an unintended spring in the system and could confuse the interaction between the propeller and governor. The possibility of air being trapped in the propeller cavity was considered so the drawings and cross sections of the engine and propeller hardware were reviewed.

Airplanes with tricycle landing gear have the engine installed horizontally; however, the engines on tail dragger airplanes such as those used in agricultural applications are at a nose-high angle when stationary on the ground. Air Tractor engineers stated that while stationary, the engine attitude is at approximately 5-degree nose-high.

When newly assembled, the engine propeller shaft (Figure 5) and the propeller cavity (Figure 6 - depicted in blue) contain only air. Once the engine is started, oil is transferred from the prop governor via the propeller oil transfer sleeve in the RGB, through the oil transfer holes in the propeller shaft and into the propeller shaft hollow center. Oil flows forward, into the propeller cavity, filling the inner cavity of the cylinder and then passes through the transfer oil holes, filling the external piston cavity. The piston cavity is a closed dome with no bleed fitting, and any air and oil trapped in the piston must leave back through the oil transfer holes in the cylinder. The propeller begins spinning as soon as the engine started and the oil entering the piston is centrifuged outward, causing any trapped air (Figure 7 – depicted in pink) to be captured at the center of the external piston. Once shut down, it is possible that the remaining air may be captured in the forward upper portion of the external piston (Figure 7 - depicted in yellow). The chance that all the air will exit the transfer holes is low if the cycles are all made with the airplane at the nose-high ground angle.

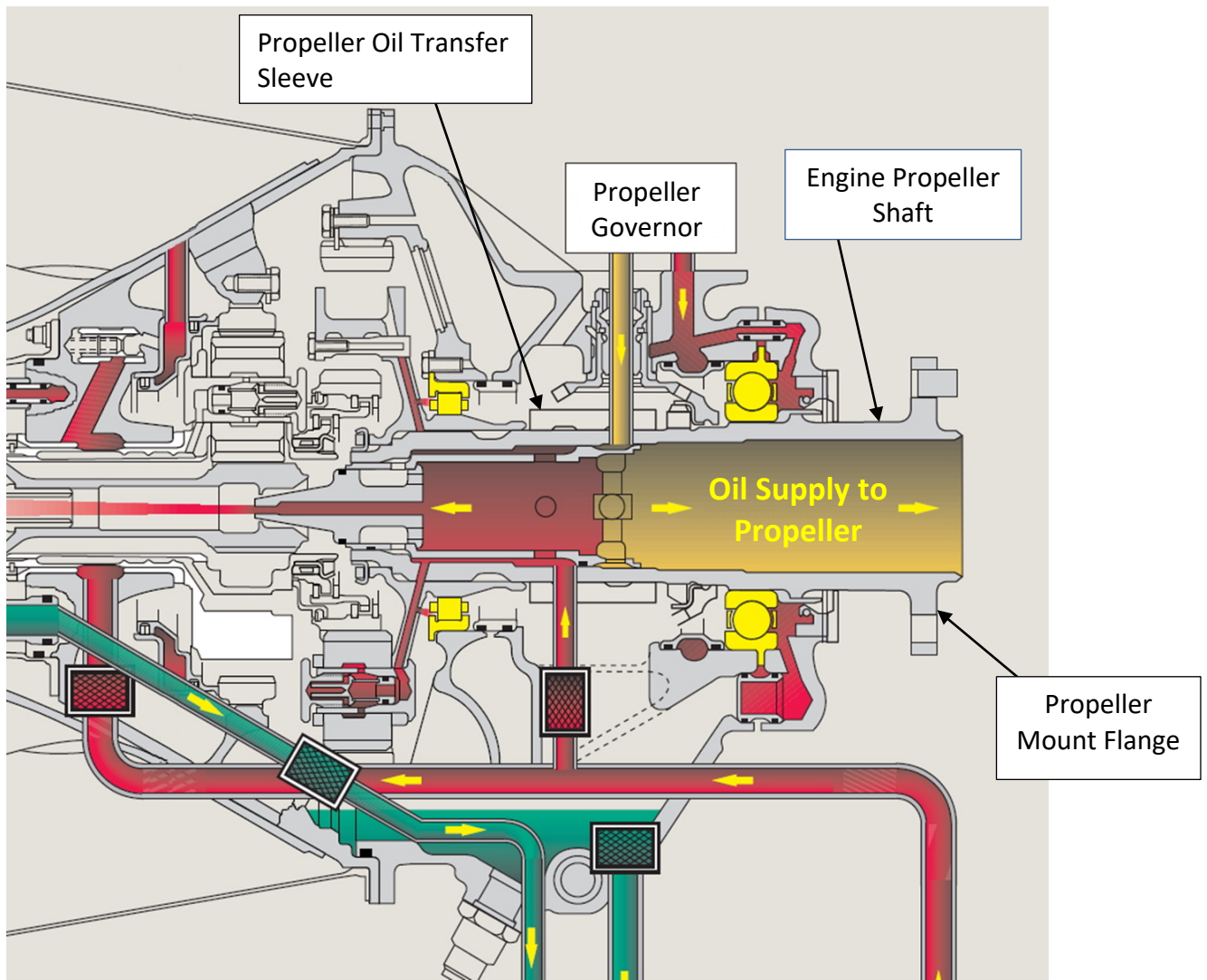


Figure 5 - PT6A Reduction Gearbox Propeller Oil Transfer Schematic (Courtesy of Pratt & Whitney Canada)

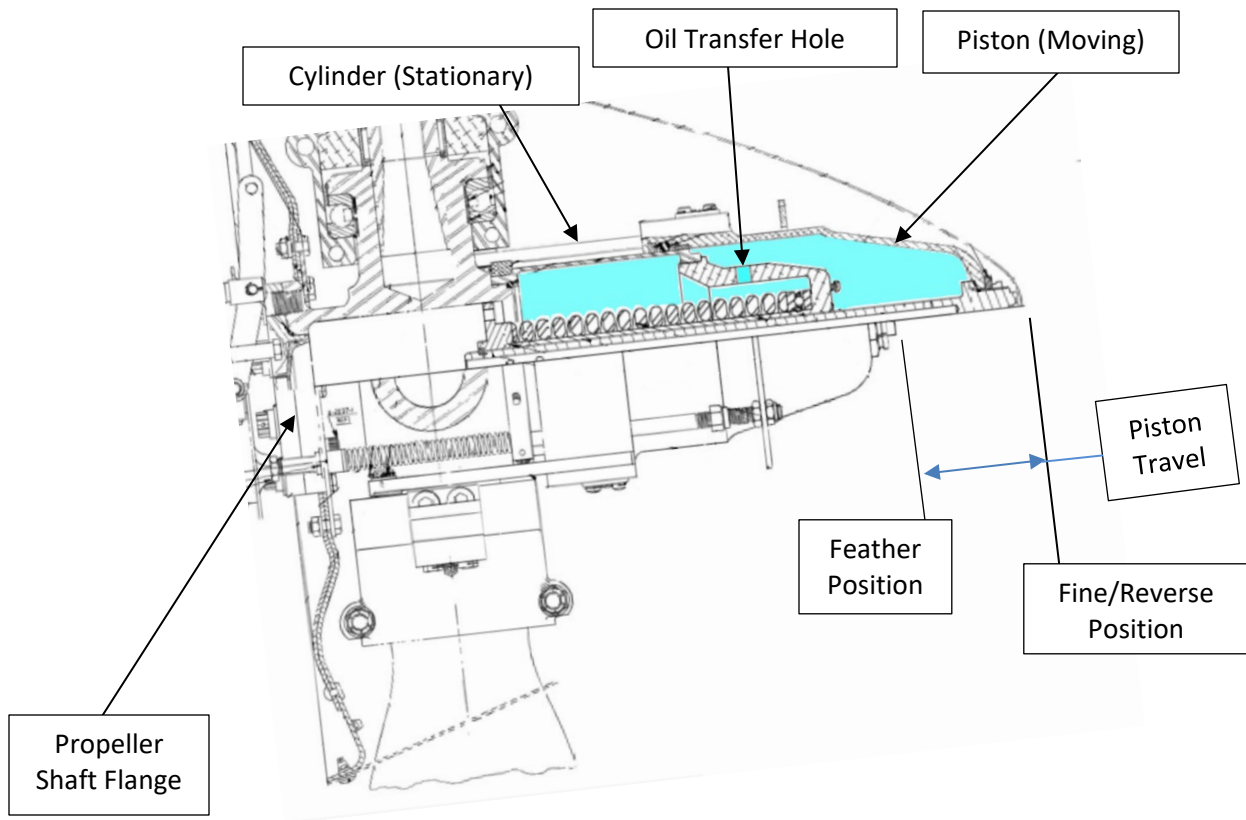


Figure 6 - Propeller Cross Section - Oil Cavities (Courtesy of Hartzell)

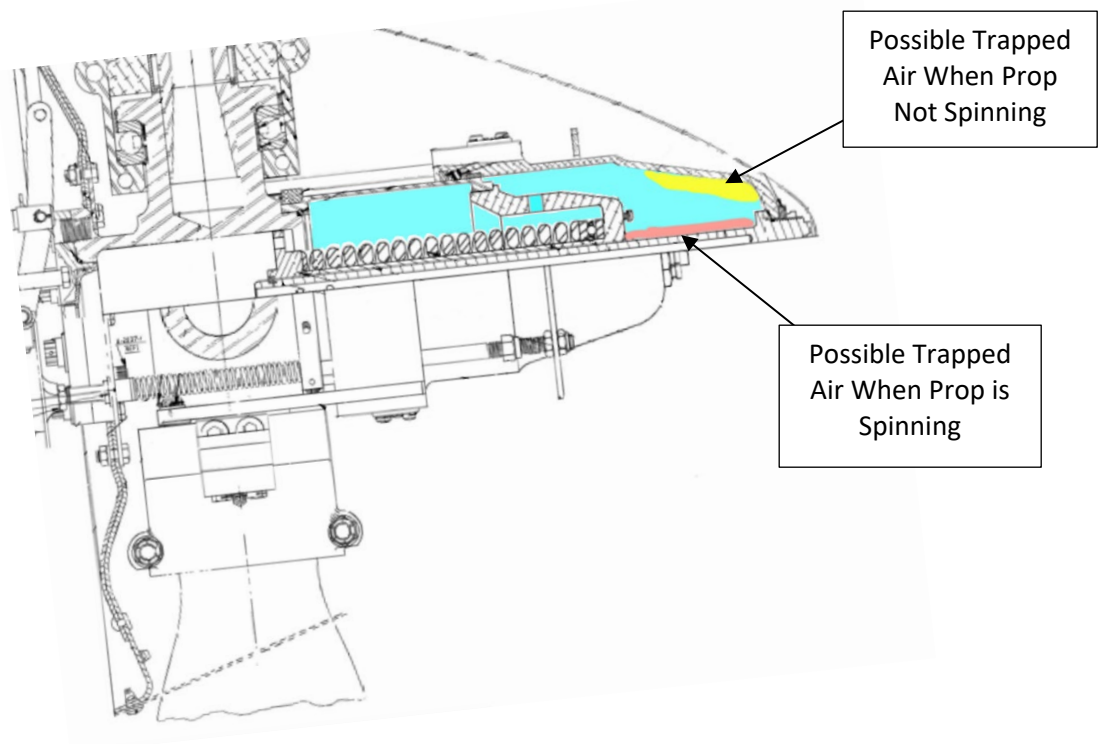


Figure 7 - Propeller Cross Section - Possible Captured Air (Courtesy of Hartzell)

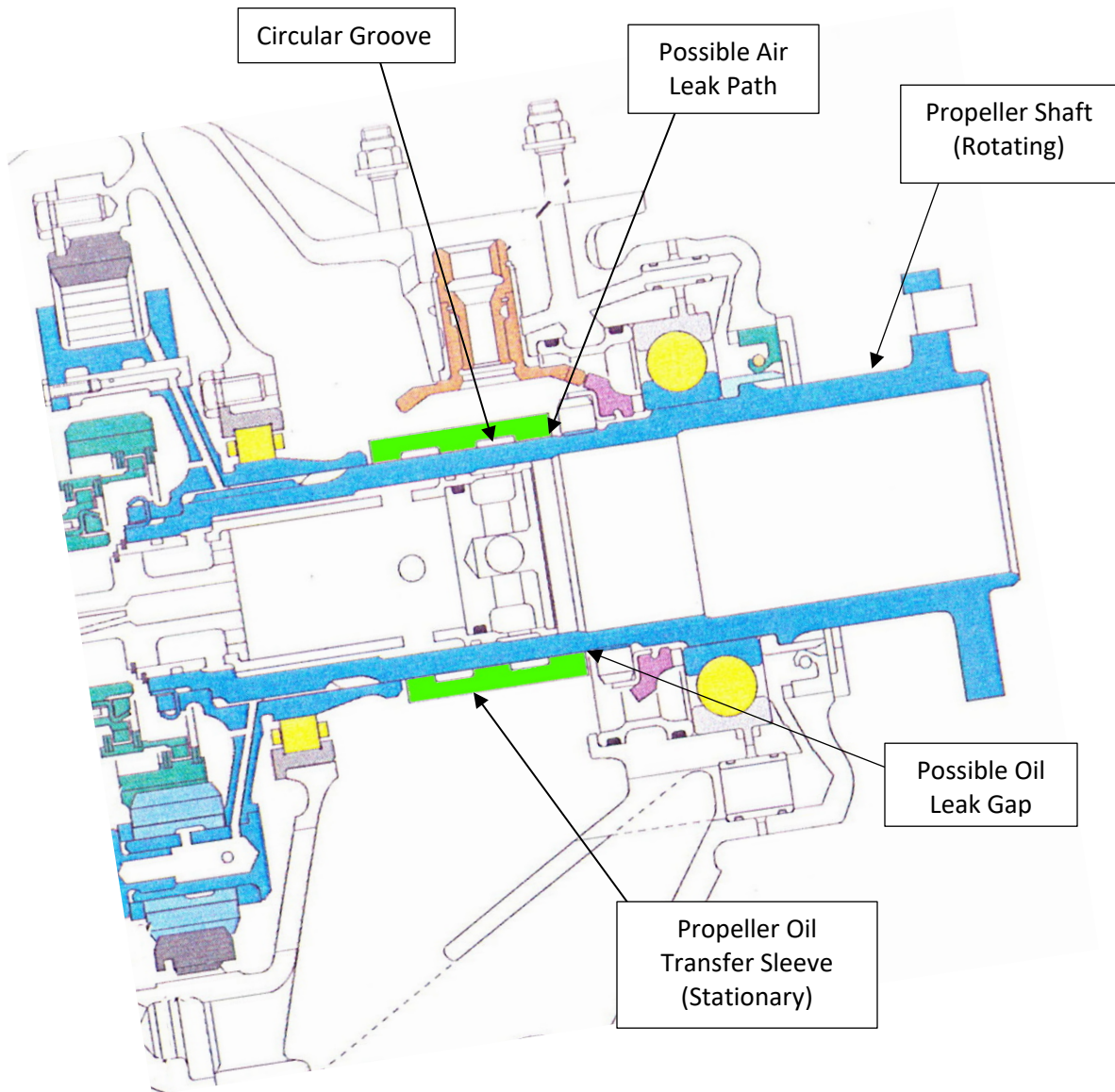


Figure 8 - Reduction Gearbox & Oil Transfer Sleeve Detail (Courtesy of Pratt & Whitney Canada)

According to the Air Tractor pilots, airplanes that have been inactive for about a month or more are highly likely to exhibit a prop surge behavior and require at least 3-5 propeller cycles to reduce their surge possibility.

An examination of the propeller oil transfer sleeve (POTS) reveals a possible oil leak path during long term inactivity (See [Figure 8](#)). The purpose of the POTS is to allow the propeller governor to add or drain oil from the propeller shaft/cylinder/piston cavity from the stationary POTS to a rotating propeller shaft. The POTS is manufactured with a

very tight tolerance fit against the journals on the propeller shaft; however, there is still a gap between the POTS and the propeller shaft journal. During operation, the oil leakage of the running seal is negligible; however, when shut down, oil can leak through the gap. For a large amount of oil to leak; however, it must be displaced with air for the flow to continue. The source of the air can be the top section of the POTS (See [Figure 8](#)). The angle of the propeller allows the air that is usually captured in the POTS circular groove to be forced out of the gap on top, while oil leaks out of the bottom gap. Additionally, the angle of the installed engine makes the propeller piston to sit higher than the POTS, causing a small head of oil pressure at the running sleeve. The behavior does not occur on engines that are installed horizontally.

D.2.6 Rigging

The rigging of the event airplane could not be tested because the components were deformed; however, rigging was not considered to be a contributing factor. According to Air Tractor, historically new Air Tractor airplanes which have encountered propeller surge and immediately examined by the factory, have not had rigging errors. Beta valve adjustment is part of the rigging adjustment and according to Air Tractor engineering is not believed to be a factor in production airplanes that have exhibited surging in the past.

D.2.7 Amber Light Illumination and Control Quadrant

The event pilot reported that he saw an illuminated amber light that he believed was a clogged fuel filter light; however, examination of the fuel system could find no fuel system anomalies. An examination of the cockpit amber warning lights revealed that the fuel filter and the prop-in-beta lights are adjacent ([Photo 17](#)). It is possible that he saw the 'prop-in-beta' warning light. A 'prop-in-beta' warning lamp is triggered if the pilot pulls the throttle lever below the ground idle detent into the beta range.

A review of the throttle lever quadrant revealed that it is not a standard Air Tractor part but rather a Kawak quadrant which can be factory installed at the request of customers. The Kawak quadrant ([Photo 18](#)) features small, compact levers (when compared to the Air Tractor quadrant) and a collar type of detent-defeat mechanism with a relatively low spring tension. It was noted that the collar can be grabbed and lifted quite easily and inadvertently compared to the Air Tractor ([Photo 19](#)) thumb operated button that requires a deliberate opposite-direction thumb motion to defeat the beta range detent. It is conceivable that the pilot, during a stressful situation, will grab the entire handle, thereby inadvertently raising the beta-detent collar, so that he would encounter no resistance at the idle detent location while retarding the power lever, allowing the lever to enter the beta range in flight.

It is also conceivable that if a pilot encounters an uncommanded large thrust fluctuation, then he may try to control the power by quickly retarding the power lever,

and if there is an easily defeated beta detent, such as in the Kawak quadrant, then it is possible that the beta mode could be selected during flight, explaining the reported illuminated amber light. According to Hartzell, the propeller was not capable of being governed during this thrust fluctuation condition, it is unlikely that the beta mode selection during this flight would have made a difference in the propeller behavior.

Harald Reichel
Aerospace Engineer – Powerplants

Photo 1 – Air Tractor AT-502



Photo 2 – AT-502 Engine Frame & Mount Damage



Photo 3 – Engine Still Attached to Airframe Mount



Photo 4 – Engine Propeller Flange – Partially Fractured

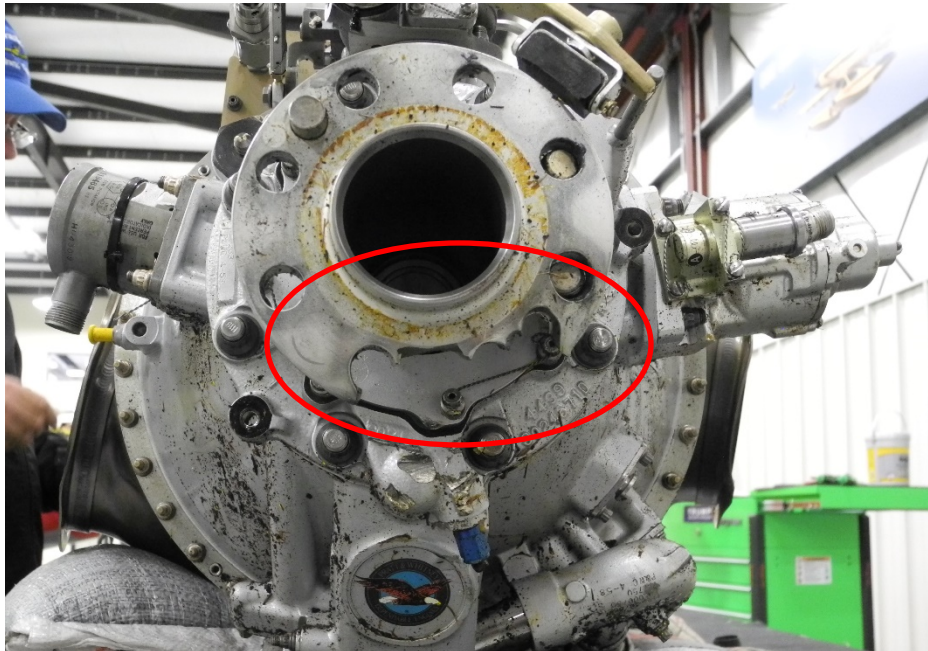
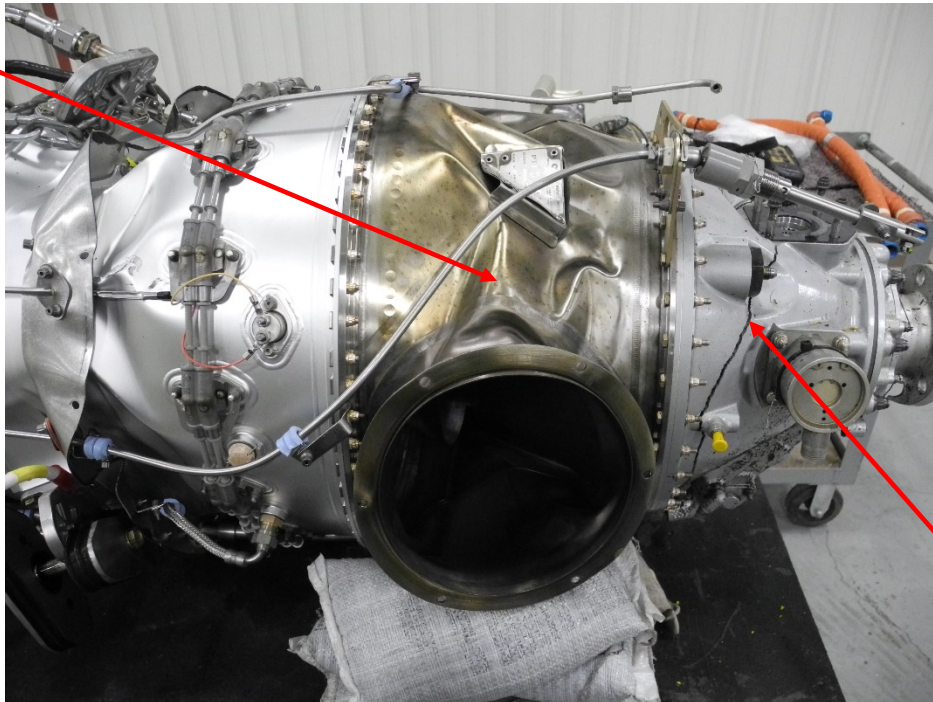


Photo 5 – PT6A-140AG Engine – Deformed Modules



Photo 6 – RGB Fractured and Exhaust Housing Buckled

Exhaust
Housing -
Buckled

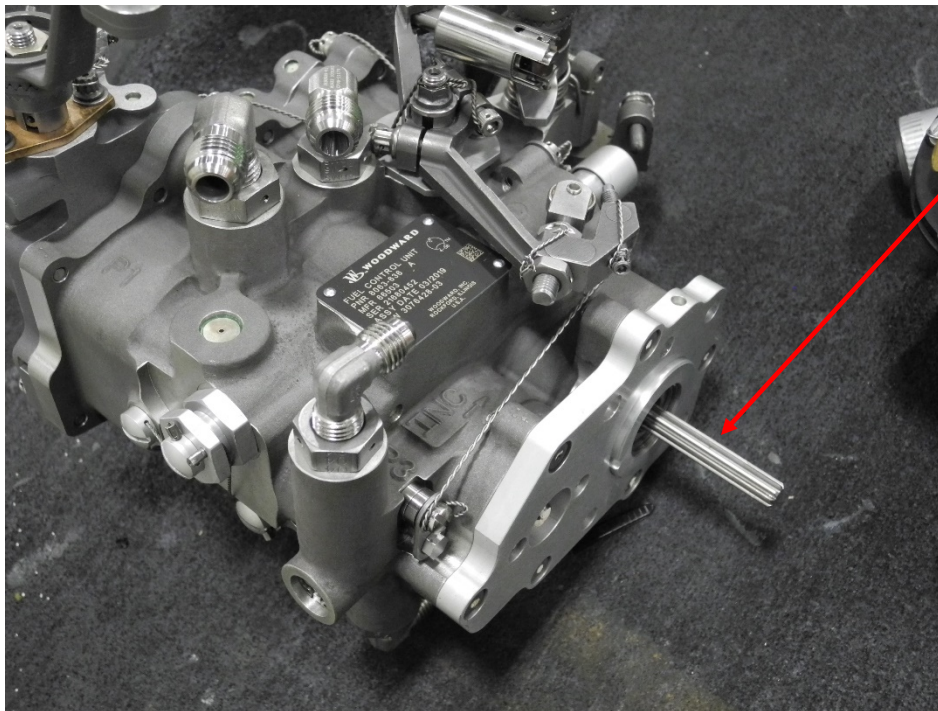


RGB
Fractured

Photo 7 - Compressor Housing – Buckled and Torn



Photo 8 – FCU – Input Spline - Undamaged



Input Spline

Photo 9 – Fuel Pump - Undamaged



Photo 10 – Propeller Governor (CSU) - Fractured



Photo 11 – Fuel Hose #2 – Internal Rubber Fracture (via Borescope)



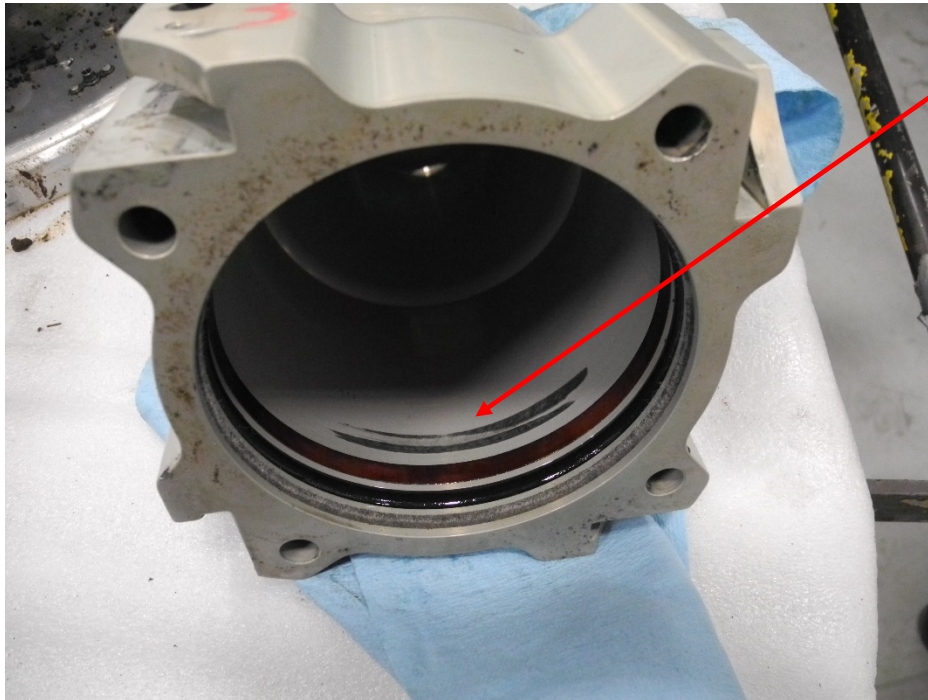
Photo 12 – Low-Pressure Airframe Electric Fuel Pump



Photo 13 – Engine Driven Fuel Pump (In-situ)



Photo 14 – Hartzell Propeller – External Piston with Impact Crease

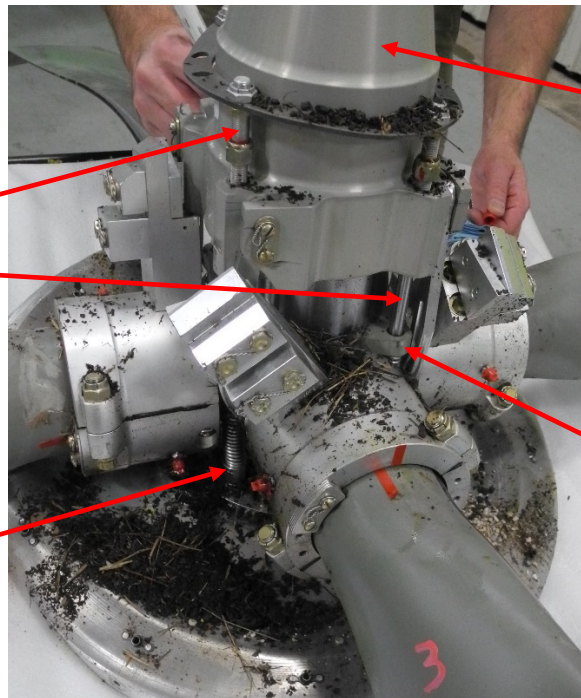


Internal Impact
Crease

Photo 15 – Propeller Blades (in Progressive Order)



Photo 16 – Propeller Hub Details



Beta
Rods

Beta Guide Lugs
(Bushings Inserted
in Guide Lug)

External Piston

Beta Guide
Collar (Bushings
Inserted in Guide
Collar)

Photo 17 – Cockpit Gauges Depicting Proximity of Amber Warning Lights



Photo 18 – Kawak Quadrant – Integrated Detent Handles Close to Control Knob



Photo 19 – Standard Air Tractor Quadrant – Note Separate Detent Handles



Appendix I

Date of Accident: August 29, 2019

Location: Olney, TX
Olney Municipal Airport (KONY)

NTSB File No.: CEN19LA295

Aircraft: Air Tractor AT-502A

Registration No.: N8517Q

Serial No.: 502A-3210 (Year of Manufacture 2019)

Operator: Lane Aviation (per NTSB Preliminary Report)

Written by: Les Doud
Air Safety Investigator – Hartzell Propeller Inc.

Report Date: July 7, 2021

Contents:

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General Information	4
Propeller Factual Findings	5
Photo List	16
Appendix 1: Propeller Servo Pressure Survey.....	19
Appendix 2: Beta System Component Measurements	20

PROPELLER TEARDOWN REPORT

Date of Investigation: November 8, 2019

Location: Air Tractor Manufacturing Facilities
1524 Leland Snow Way
Olney, TX 76374

Propeller Model: HC-B4TN-3C with T10702NS Blades

Representatives:

Les Doud	Hartzell Propeller Inc. ASI
Harry Reichel	NTSB Powerplant Group Chairman
Dakota Lowe	Air Tractor ASI
Kyle Schroeder	Air Tractor ASI

ACCIDENT SYNOPSIS - The following is excerpted from the NTSB preliminary report.

"On August 29, 2019, about 1100 central daylight time, an Air Tractor AT-502A airplane, N8517Q, collided with terrain during a forced landing shortly after takeoff from Olney Municipal Airport (ONY), Olney, Texas. The commercial pilot sustained minor injuries, and the airplane was substantially damaged. The airplane was registered to and operated by Lane Aviation as a Title 14 *Code of Federal Regulations (CFR)* Part 91 business flight. Day visual meteorological conditions prevailed, and no flight plan was filed for the flight that had the intended destination of Lane Airpark (T54), Rosenberg, Texas.

According to maintenance documentation, the airplane had accumulated about 1 hour of flight time before it received its airworthiness certificate on August 26, 2019. The pilot reported that the purpose of the flight was to fly the airplane from the Air Tractor factory to his company's base at T54. The pilot reported that he arrived at the airport between 0930 and 1000, and that it took about an hour to review paperwork and the logbooks before he accepted the airplane. The pilot stated that he did not observe any anomalies during his 15 minute preflight inspection. The airplane had been previously topped-off with fuel (234 gallons), and fuel samples obtained during his preflight inspection were free of water and particulate. The pilot noted that the airplane was equipped with a ferry tank system; however, the ferry tank (hopper) did not contain any fuel.

The pilot reported that the engine started normally and that he did not observe any anomalies on the engine gauges. The pilot stated that he completed a brake check and cycled the propeller 3 times while taxiing to runway 17. The pilot noted that he did not operate the engine on the ferry tank because it was empty, and that the taxi and takeoff were performed with the fuel selector positioned to the main fuel tank. The pilot stated that after he taxied onto runway 17 he locked the tailwheel and increased engine power to 1,500 lbs of torque as he held the brakes. The pilot increased engine power to 2,200-2,300 lbs of torque during the takeoff roll and achieved a normal liftoff at 95-100 knots. The pilot reported that he maintained a higher-than-normal climb angle to quickly ascend to a safe altitude above the runway; however, at 200 ft above ground level (agl) the engine power began to surge between idle and full power.

The pilot reported that he did not believe there was adequate runway remaining to ensure a safe landing, so he entered a left turn to land on runway 31. The pilot stated

that during the turn he saw an amber annunciator panel light illuminated, which he believed to be the fuel filter warning light. The pilot stated that he was unable to complete the turn to runway 31 without entering an aerodynamic stall, so he leveled the wings and made a forced landing in a hay field to the southeast of runway 31. The pilot reported that the airplane landed hard on the left main landing gear before it collided with a tree stump. The airplane then swerved to the left and down into a ditch."

SUMMARY AND ANALYSIS OF FINDINGS

The accident propeller was recovered from the accident scene and presented for examination as shown in Photo #1 at the Air Tractor manufacturing facilities in Olney, TX on November 8, 2019. The propeller was disassembled primarily to remove this piston and blades. Measurements of impact marks on the cylinder surface and piston internal surface were recorded and analyzed to aid in blade angle determination. Blade damage was assessed to aid in determination of blade section impact angles and thus engine power state at initial impact.

There were cylinder and piston impact marks that indicated the propeller was operating in the normal operating blade angle range at initial impact. There was no damage to indicate the propeller was feathered or in the beta/reverse range at the time of impact. All four blades remained attached via the retention clamps, no pilot tubes were fractured and there were no blade fractures. Blade damage that included camber side chordwise/rotational abrasion, bending aft, bending opposite rotation, leading edge gouging with material deformation towards low pitch and progressive compound bent/twisting towards low pitch was consistent with impact at a relatively shallow aircraft impact angle while rotating at a low power setting. Piston impact marks representing blade angle near the flight idle range are consistent with the blade damage, indicating rotation under low power and at slightly negative blade section impact angles.

Additional testing and examinations were conducted after the initial propeller exam in November 2019. Appendix 1 summarizes the propeller servo pressure testing to confirm servo pressures did not exceed any limitations. Appendix 2 summarizes the dimensional inspection of the beta components and found no obvious conditions that would cause binding. Several tests were conducted throughout 2020-2021 to evaluate guide bushing susceptibility to swelling under moisture or chemical exposure. The lab testing confirmed that the ID of the guide lug and guide collar bushings can shrink by approximately 0.001 inch when the bushings come into contact with water. The bushings typically returned to their original diameter when allowed to dry. Turbine oil did not have any effect on the bushings diameters. Lab testing also confirmed that certain chemical solutions can cause the bushings diameters to shrink by approximately 0.001 inch. The bushings typically returned to their original diameter when allowed to dry.

CONCLUSIONS

There were no discrepancies noted that would prevent or degrade normal operation prior to impact with terrain. Piston marks and blade damage indicated the propeller was operating at low blade angles with low power at initial impact. All damage was consistent with high impact forces. There were no conditions found that would cause beta system binding on a propeller with only one hour of operation and never exposed to moisture and/or chemicals typically used in Ag operations.

GENERAL INFORMATION

Propeller Description: This propeller used on the PT6A-140AG powered AT-502A is a 108" diameter, 4-blade, single-acting, hydraulically operated, constant speed model with feathering and reversing capabilities. Oil pressure from the propeller governor is used to move the blades to the low pitch (blade angle) direction. Blade mounted counterweights and feathering springs actuate the blades towards the high pitch direction in the absence of governor oil pressure. The propeller incorporates a Beta mechanism that actuates when blade angles are lower than the flight idle position. The blades are of aluminum construction. The hub and blade clamps are steel. Propeller rotation is clockwise as viewed from the rear. A propeller cutaway sketch is shown in Figure 1.

Installation Data: Refer to Hartzell Installation Data Sheet No. 3340 and Aircraft TCDS A17SW for the propeller settings referenced below:

(Angles referenced at the 42-inch radius)

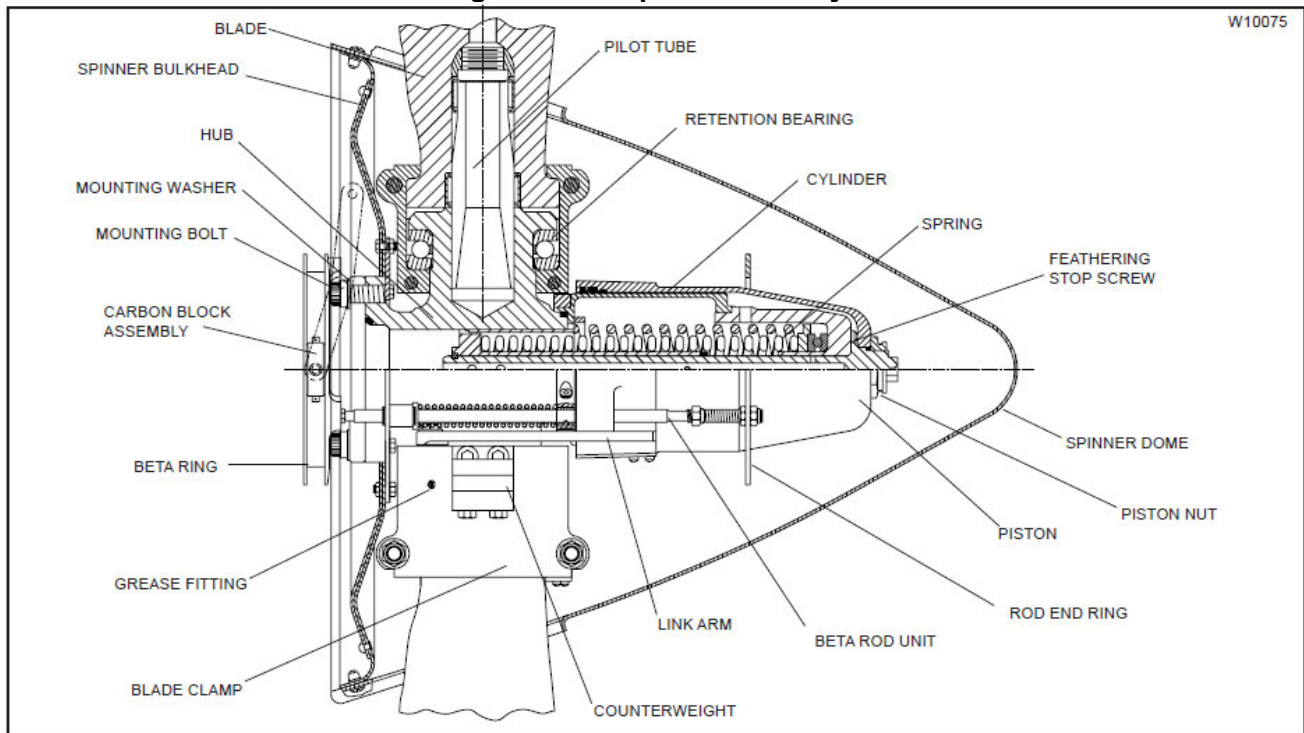
Reverse: -15.0 ± 0.5 degrees

Low Pitch/Beta Pick-Up: 8.2 ± 0.1 degrees

Feather: 80.7 ± 0.5 degrees

Counterweight: Positive

Figure 1 – Propeller Cutaway Sketch



PROPELLER EXAM FACTUAL FINDINGS

Propeller Model: HC-B4TN-3C with T10702NS blades

Propeller Assembly S/N: CDA5796

Service History: The propeller was new on March 8, 2019. There had not been any service on the propeller since manufacture.

	<u>S/N</u>	<u>Date of Manufacture</u>	<u>TTSN</u>	<u>TSO</u>
Hub/Factory	D8474A	3/8/19	1	NA
Blade 1	L95795	3/6/19	1	NA
Blade 2	L95790	3/6/19	1	NA
Blade 3	L95794	3/6/19	1	NA
Blade 4	L94250	12/7/18	1	NA

Blade Orientation: The blades were identified as 1-2-3-4-5 clockwise as viewed from the rear of the propeller. The hub serial number was between the #1 and #4 blades.

“As Received” Condition: The propeller fractured from the engine propeller shaft mounting flange during the impact sequence and was presented for examination as shown in Photo #1. The spinner dome was removed by Air Tractor personnel before this examination. The beta ring was bent and a portion of the aft flange – roughly the size of the beta carbon block – was fracture-separated. All four blades were bent aft and twisted leading edge down in varying degrees. The piston was extended approximately 2-2 1/16 inches from the beta rod guide collar. All four link arms appeared connected at both the link screw and link pins with the #2 link arm visibly bent in compression. The beta guide rod collar was gouged at the #1, #2 and #3 blade positions.

Spinner Dome: The spinner dome that had been removed prior to the propeller examination and is shown in Photo #2. The dome had signatures of spiral scoring and was crushed between blades #1 and #2 and torn in compression at blade positions #3 and #4. There were counterweight punctures or impressions at all four blade locations at approximately the reverse-stop position (counterweights approximately vertical/in-line with the axis of rotation).

Spinner Bulkhead: The spinner bulkhead and dome mounting flange was bent forward in the area between blades #1 and #2.

Propeller Cycling: Propeller cycling was not attempted due to damage of the pitch change components.

Engine/Propeller Mounting: (see Photo #3) A portion of the propeller mounting flange remained attached to the propeller hub with one mounting bolt still in position and one bolt loosely attached to it via safety wire. The shank of a third mounting bolt remained in the propeller hub but the head had fracture-separated. One drive dowel remained lodged into the propeller hub. Two propeller mounting bolts had pulled from the propeller hub and remained loosely connected to the engine propeller flange.

Blade/Clamp Rotation:

Blade	Blade/clamp Angle As-Received	Blade Slip in Clamp?	Rotation of clamp possible?
1	Normal range of operation	No	No
2	Low pitch/normal range of operation	Rotated approximately 55-65° towards low pitch	No
3	Normal range of operation	Rotated approximately 10-15° towards high pitch	No
4	Normal range of operation	No	No

Pitch Stops: The piston was removed from the hydraulic unit but the cylinder, pitch change rod and feathering springs were not removed.

Low Pitch/Reverse Stop: The beta pick-up nuts, beta guide ring, and beta rods were present. The guide ring was bent due to impact forces. The reverse stop sleeves were not observed.

Feather Stop Screws: The feather stop screws appeared intact and undamaged (see Photo #4).

Beta rods: The beta rods were intact but bent opposite rotation.

Piston: The piston was intact but had scuffing from contact with the spinner dome at forward corner/nose. The piston nut was intact and tight. The piston was jammed by over-rotation of the clamps/link arms in a position approximately 2 – 2 1/16 inches from the beta guide collar. There were gouges near the link pin/link arm attachment ears adjacent to blades #2 and #3. The piston was otherwise intact and functional. The piston P/N was C-2303-3 Rev. AU, S/N 190115. There were several circumferential marks on the internal surface made by contact with the top corner of the cylinder during initial impact and following impact sequence (see Photo #5). The marks measurements and interpretation are presented in the following Table #1.

Table #1 - Summary of Piston Impact Signatures

Internal Marks from Bottom Piston Edge	Approximate Equivalent Blade Angle	Pre-impact Confidence Level / Why?
1.68 to 1.72"	-7.5 to -9°	Medium, in reverse range, impact sequence marks
1.31"	< -15°	Low, lower than reverse stop
2.19 – 2.22"	8 – 9°	High, near low pitch/flight idle hydraulic stop, consistent with blade and other damage
3.25"	39.5°	Medium, in normal range but higher than power and flight condition would require
3.34"	42.2°	Medium, in normal range but higher than power and flight condition would require

Link Arms: All four link arms remained attached at their link screw and link pin attach points.

Link Arm	Link Arm Condition
1	Bent in compression
2	Bent in compression, twisted, bent laterally
3	Bent in compression, link screw elongated
4	Bent in compression

Cylinder: The cylinder was not removed from the hub during the examination. There was a crease/dent in the cylinder wall approximately 1.63 – 1.81” from the top corner of the cylinder and adjacent to the #2 and #3 blades (see Photo #6). These marks are approximately equivalent to a blade angle of -4.4 to -10.8°. The marks are consistent with the piston marks that represented blade angles of -7.5 to -9° and were likely made during the impact sequence.

Feathering Spring Assembly: The feathering spring was not removed or observed. However, the feathering spring was intact and compressed in the as-presented condition. The spring tension was released by removing the piston nut during disassembly.

Pitch Change Rod: The pitch change rod was not removed. It appeared intact and undamaged in its installed state.

Clamps and Counterweights: (see Photo #7) All clamp bolts were present and secure.

Clamp Pos.	Clamp S/N	Clamp Condition	Counterweight Condition
1	EM34426	Link screw deformed opposite low pitch	Intact and undamaged
2	EM34427	Link screw deformed opposite low pitch	Arm corner dented
3	EM34436	Link screw deformed opposite low pitch	Arm corner dented
4	Em34476	Appeared intact and undamaged	Intact and undamaged

Hub Unit: The hub unit/spider remained intact with no remarkable fractures or cracks. All four pilot tubes remained intact and in the hub. The cylinder attachment appeared intact and damaged. There was only one impression mark on a blade arm flange at blade #2. That mark was centered at 80° aft the plane of rotation in the trailing edge quadrant as detailed in Table #2. Additionally, blades #2 and #3 were jammed onto the pilot tube due to impact damaged and had to be wedge-hammered off assembly.

Blade Properties: Photos #8 through #12

Blade # 1

Camber side	Chordwise/rotational abrasion
Face side	Chordwise/rotational abrasion within 1" of tip
Bend	Aft
Twist	Leading edge towards low pitch near tip
Lead edge damage	Gouges 13" and 32" from tip with material deformation toward low pitch
Trail edge damage	Localized bend 13" from tip
Blade bearings	Intact
Butt/shank impact marks	NA, hub pilot tube shoulder impact depression
De-Ice boot	NA

Blade # 2

Camber side	Chordwise/rotational abrasion, spanwise abrasion mid-blade
Face side	Spanwise abrasion in mid-blade area, some chordwise/rotational abrasion near tip
Bend	Aft and opposite rotation
Twist	Twisted leading edge down towards low pitch outboard of shank
Lead edge damage	Gouge 5" from tip, material deflection towards low pitch
Trail edge damage	Wave-like buckling bend 7" from tip
Blade bearings	Intact
Butt/shank impact marks	Impact crescent, hub pilot tube shoulder impact depression
De-Ice boot	NA

Blade # 3

Camber side	Chordwise/rotational abrasion
Face side	Chordwise/rotational abrasion last 12" isolated to ~0.20c
Bend	Aft and opposite rotation
Twist	Twisted leading edge down toward low pitch outboard 75% of blade
Lead edge damage	Nicks, material deformation towards low pitch
Trail edge damage	Bent 2" in tip radius
Blade bearings	Intact
Butt/shank impact marks	NA, hub pilot tube shoulder impact depression
De-Ice boot	NA

Blade # 4

Camber side	
Face side	Chordwise/rotational abrasion last 10" isolated to ~0.40c
Bend	Aft and opposite rotation
Twist	Leading edge down towards low pitch outboard 50%
Lead edge damage	Nicks, otherwise not remarkable
Trail edge damage	Not remarkable
Blade bearings	Intact
Butt/shank impact marks	Hub pilot tube shoulder impact depression
De-Ice boot	NA

Table #2 - Summary of Blade Butt – Hub Arm Impact Signatures

Blade Number	Blade Arm Mark	Blade Butt Mark	Slippage	Resulting Blade Angle	Confidence Level / Why?
#2	80° face/trail edge quadrant	87° face/trail edge quadrant	~55-65° towards low pitch	19-29° w/ slippage -26° w/o slippage	Medium, normal range of operation but higher than power and flight condition require Low, beyond reverse stop

Photo #1 – Propeller as-presented



Photo #2 – Spinner dome



Photo #3 – Propeller mounting flange and beta ring



Photo #4 – Feather stop screws



Photo #5 – Representative impact marks on internal surface of piston

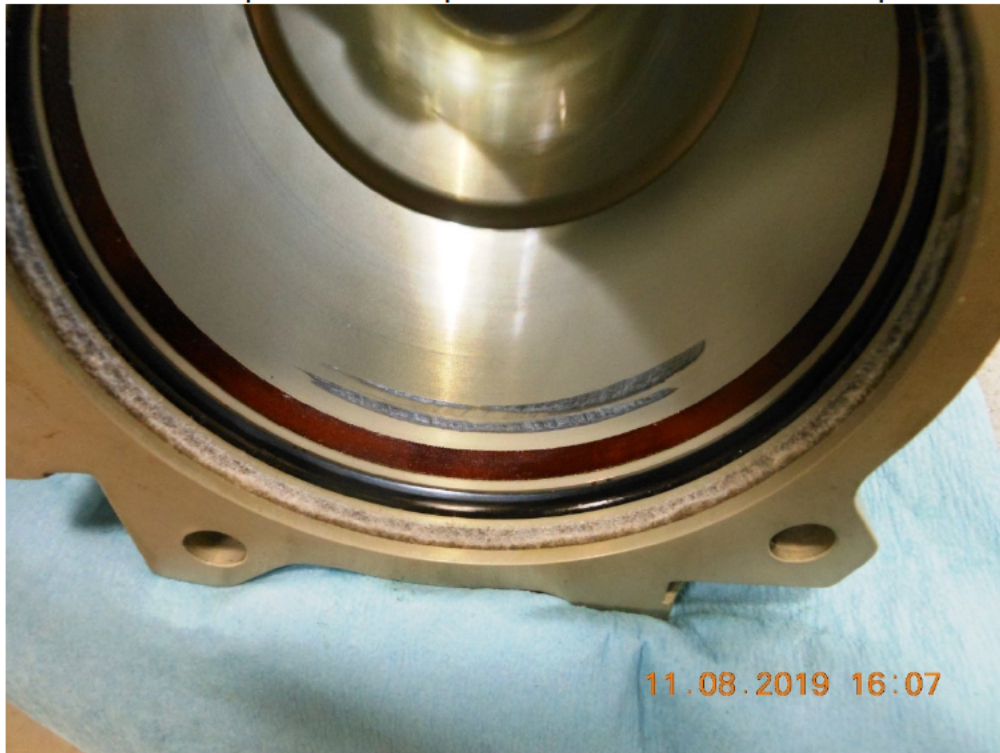


Photo #6 – Cylinder impact marks

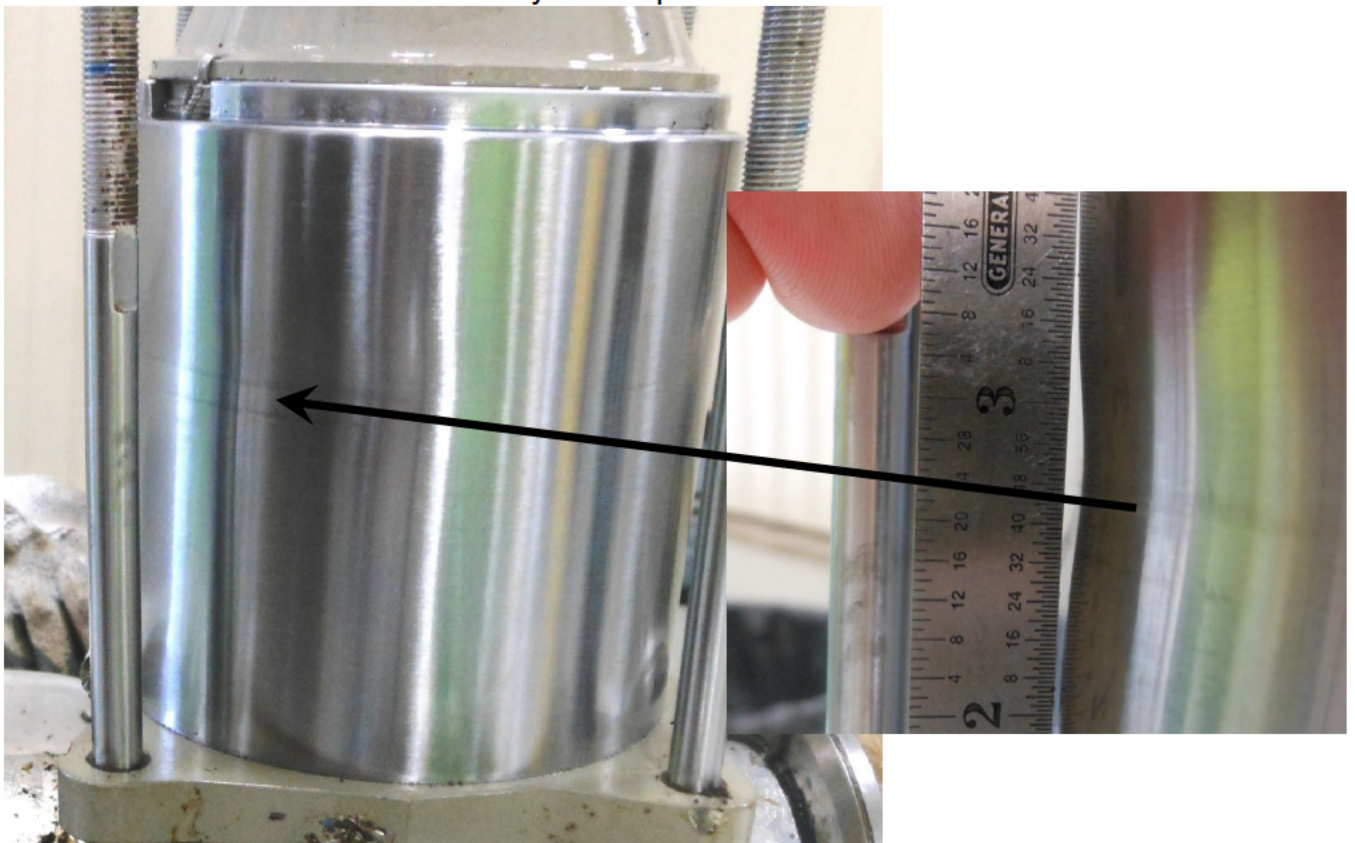


Photo #7 – Blade retention clamps



Photo #8 – Blade #3 face side – typical degree of chordwise/rotational abrasion



Photo #9 – Blade progressive, compound bend and twist



Photo #10 – Blade progressive, compound bend and twist



Photo #11 – Blade camber side



Photo #12 – Blade face side



PHOTO LIST

NOTE: The following is a list of the original and unedited digital photographs. The photographs are available in digital format (CD, memory stick/card, FTP). The numbering sequence may not be chronological as some may have been deleted if out-of-focus, too dark, redundant, etc. Photos used in the text of this report are taken from photos on this list but may have been adjusted from the original. Modifications to images used in the report are limited to cropping, magnification, file compression, or enhancement of color, brightness, or contrast for the sole purpose to improve clarity of the report. No other alterations are permitted.

<u>Picture File Name</u>	<u>Description</u>
DSCN0289.JPG	Propeller as-presented from blade #4 tip
DSCN0290.JPG	Propeller as-presented from blade #1 tip
DSCN0291.JPG	Propeller as-presented from blade #2 tip
DSCN0292.JPG	Propeller as-presented from blade #3 tip
DSCN0293.JPG	Propeller as-presented #1 shank/clamp area
DSCN0294.JPG	Propeller as-presented #2 shank/clamp area
DSCN0295.JPG	Propeller as-presented #2-#3 shank/clamp area
DSCN0296.JPG	Propeller as-presented #3 shank/clamp area
DSCN0297.JPG	Propeller as-presented #4 shank/clamp area
DSCN0298.JPG	Propeller as-presented piston displacement A
DSCN0299.JPG	Propeller as-presented piston displacement B
DSCN0300.JPG	Propeller as-presented, top of piston/beta rod guide ring
DSCN0301.JPG	Propeller as-presented #2 link arm buckled
DSCN0302.JPG	Mounting flange
DSCN0303.JPG	Beta ring
DSCN0304.JPG	Aft side of spinner bulkhead
DSCN0305.JPG	Cylinder
DSCN0306.JPG	Cylinder dent/crease
DSCN0307.JPG	#2 blade arm flange and pilot tube
DSCN0308.JPG	#3 blade arm flange and pilot tube
DSCN0309.JPG	#4 blade arm flange and pilot tube
DSCN0310.JPG	#1 blade arm flange and pilot tube
DSCN0311.JPG	Feather stop screws and forward spring cup
DSCN0312.JPG	Spinner dome counterweight puncture at #4
DSCN0313.JPG	Spinner dome counterweight puncture at #2
DSCN0314.JPG	Spinner dome tear at #3
DSCN0315.JPG	Spinner dome crushing and abrasion/scoring at #2
DSCN0316.JPG	Spinner dome crushing and abrasion/scoring at #1
DSCN0317.JPG	Piston internal contact mark A
DSCN0318.JPG	Piston internal contact mark B
DSCN0319.JPG	Piston internal contact mark C
DSCN0320.JPG	Piston internal contact mark D
DSCN0321.JPG	Internal piston, feather stop screw contact area
DSCN0322.JPG	Piston internal contact mark E

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DSCN0323.JPG	Piston internal contact mark F
DSCN0324.JPG	Piston ID markings
DSCN0325.JPG	Blade model/S/N decal
DSCN0326.JPG	#3 piston link arm attach point
DSCN0327.JPG	#4 link arm
DSCN0328.JPG	#3 link arm
DSCN0329.JPG	#1 link arm
DSCN0330.JPG	#2 link arm
DSCN0331.JPG	#3 link arm link pin hole end
DSCN0332.JPG	#4 link arm link pin hole end
DSCN0333.JPG	#1 clamp
DSCN0334.JPG	#1 link screw
DSCN0335.JPG	#2 clamp
DSCN0336.JPG	#2 link screw
DSCN0337.JPG	#3 clamp
DSCN0338.JPG	#3 link screw
DSCN0339.JPG	#4 clamp
DSCN0340.JPG	Clamps and hardware bags
DSCN0341.JPG	Blades face side
DSCN0342.JPG	Blades lead edge view
DSCN0343.JPG	Blades trail edge view
DSCN0344.JPG	Blades #1 and #4 face side tip area
DSCN0345.JPG	Blade #3 face side tip area
DSCN0346.JPG	Blade #2 face side tip area
DSCN0347.JPG	Blade #1 butt
DSCN0348.JPG	Blade #4 butt
DSCN0349.JPG	Blade #3 butt
DSCN0350.JPG	Blade #2 butt
DSCN0351.JPG	Blades camber side
DSCN0352.JPG	Blades camber side lead edge view
DSCN0353.JPG	Blades camber side trail edge view
DSCN0354.JPG	Blades #1 and #4 camber side tip area
DSCN0355.JPG	Blade #3 camber side tip area
DSCN0356.JPG	Blade #2 camber side tip area
DSCN0357.JPG	Blades #2 and #3 camber side mid-blade-to-tip
DSCN0358.JPG	Blades lead edge view in sequence of rotation/impact A
DSCN0359.JPG	Blades lead edge view in sequence of rotation/impact B
DSCN0360.JPG	Blade butt #2 with impact crescent markings A
DSCN0361.JPG	Blade butt #2 with impact crescent markings B
DSCN0362.JPG	Blade arm flange #2 with impact crescent markings
DSCN0363.JPG	Hardware bags
DSCN0908.JPG	Guide lug bushings A
DSCN0909.JPG	Guide lug bushings B
DSCN0910.JPG	Beta rods A
DSCN0911.JPG	Beta rods B
DSCN0912.JPG	Guide collar A
DSCN0913.JPG	Guide collar B
DSCN0914.JPG	Beta rod measurement

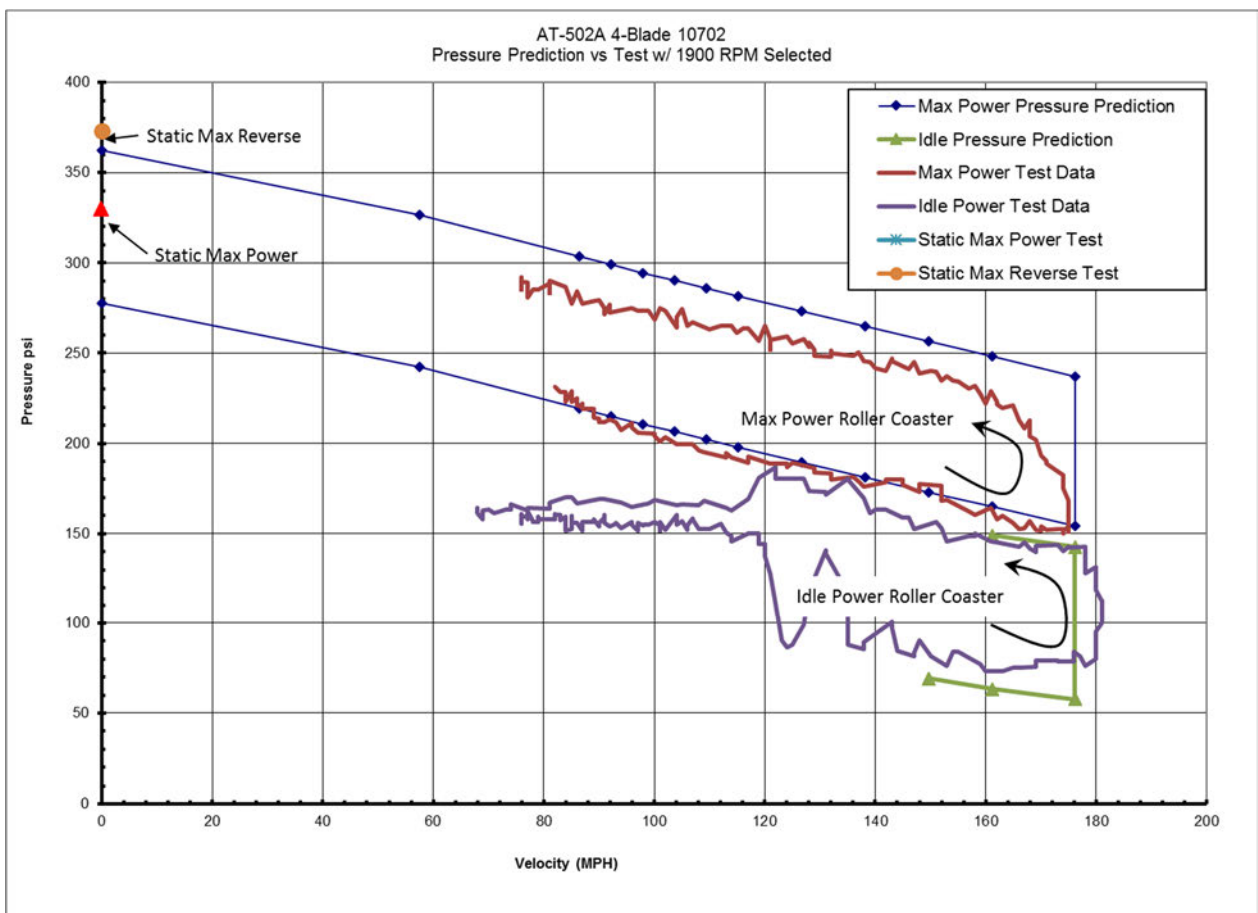
Aircraft Accident/Incident Report No.: 190829

IMG_0669.JPG	Propeller hub assembly as-presented A
IMG_0670.JPG	Propeller hub assembly as-presented B
IMG_0671.JPG	Propeller hub assembly as-presented C
IMG_0672.JPG	Propeller hub assembly as-presented D

Appendix 1 – Propeller Servo Pressure Survey

A propeller servo pressure survey was conducted by Air Tractor on an exemplar AT-502A with the PT6A-140AG engine on 4/29/2020 and 4/30/2020. A plot of the recorded pressures compared to the predicted pressures is shown in Figure 2. As shown in Figure 2, all governing servo pressures were adequately below the maximum relief setting of the governor (385+/-15). A margin of 50 psi or greater was maintained at V_{NE} with idle power.

Figure 2 – Propeller Servo Pressure Survey



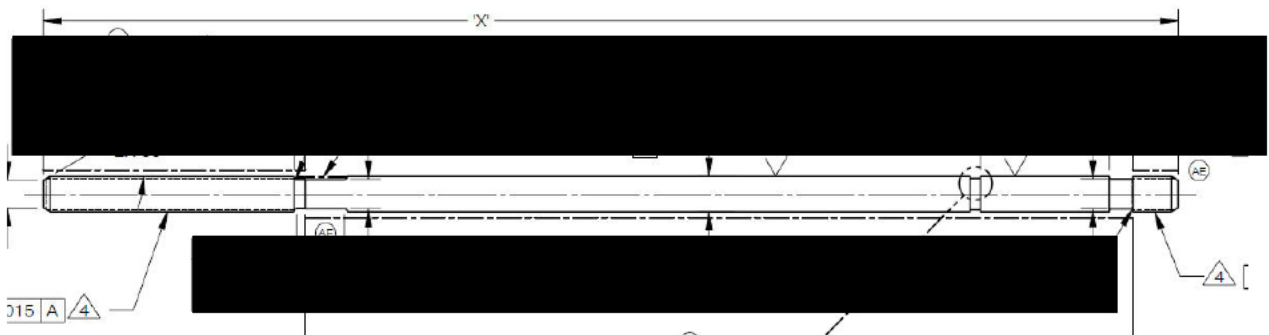
Appendix 2 – Beta System Component Measurements

The following beta system components on the accident propeller were measured at Air Tractor in Olney, TX on 4/22/2020.

Beta Rods P/N B-3475A-3

Beta Rod No.	Aft position going through guide lug	Fwd position going through guide collar
1	0.3734	0.3731
2	0.3739	0.3734
3	0.3733	0.3732
4	0.3733	0.3733

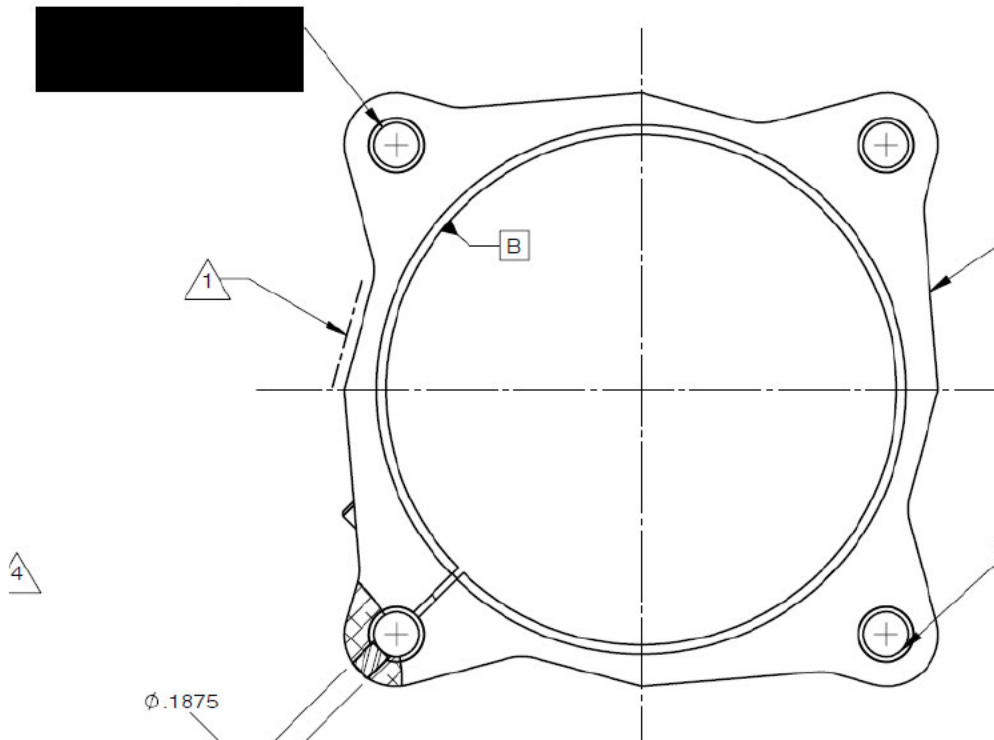
As you can see from the drawing below, all the rods were within spec.



Guide Collar P/N 834-13

The guide collar bushings were measured using a pin gage of 0.380 and it fit snugly through all four approximately equally.

As shown in the drawing below, all were slightly below spec based on the pin gage fit.



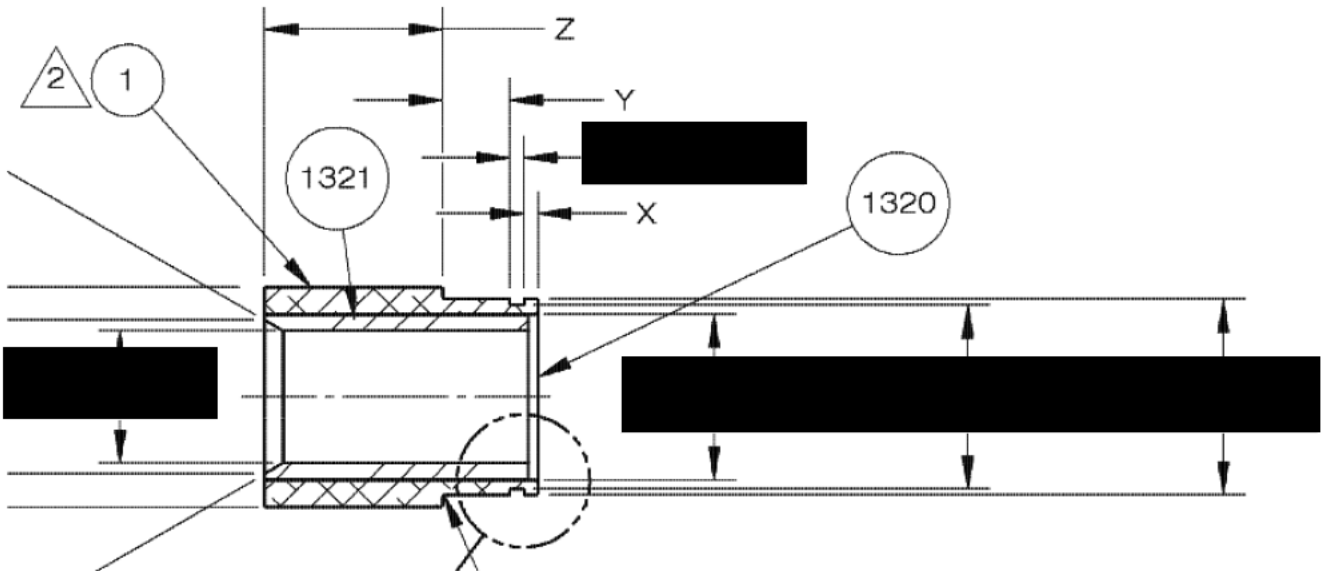
On 4/24/20 Hartzell QA measured the bushing IDs on all 12 in-stock Beta Guide Collars using the HP1126 calibrated tool. All IDs were within spec. All Guide Collars in-stock were manufactured in 2020.

Guide Lug P/N A-3067-2

The guide lug bushings were also measured using pin gages.

Guide lug location	ID
1	0.375 was loose and we didn't have a 0.376, 0.377 would not go
2	0.375
3	0.375
4	0.375

As shown in the drawing below, these bushings didn't meet spec based on using a pin gage method. Location #1 would likely meet spec but we didn't have a 0.376 pin gage.



On 4/24/20 our QA measured the bushing IDs on 151 of 358 Guide Lugs in-stock using the HP3924 calibrated tool. All IDs measured were within spec. All Guide Lugs in-stock were manufactured in 2020.

Below is the Propeller Maintenance Manual No. 118F inspection callout for the guide lug bushing and repair if necessary.

(2) Measure the guide lug bushing ID.

The maximum permitted bushing ID is 0.383 inch (9.72 mm).

If the guide lug bushing is loose, or the ID greater than the maximum permitted serviceable limit, the guide lug bushing must be replaced in accordance with the Special Adhesive and Bonding chapter of Hartzell Propeller Inc. Standard Practices Manual 202A (61-01-02).

During assembly of the propeller the following caution is presented in Manual 118F

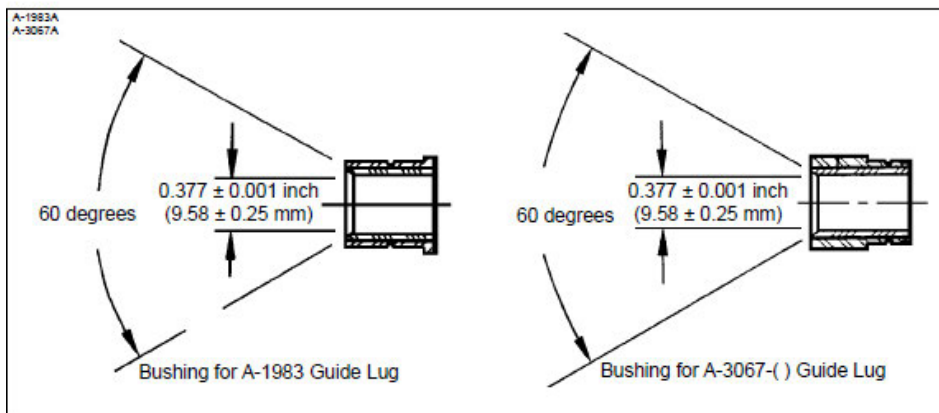
CAUTION: IF THE BETA ROD GUIDE LUGS CANNOT BE TURNED SMOOTHLY, WITHOUT STICKING, WITH THE PROPELLER IN REVERSE POSITION, THE LUGS ARE BINDING AND THE GUIDE COLLAR MUST BE LOOSENEED, THE SPINNER SUPPORT PLATE MUST BE ADJUSTED, OR THE PISTON AND GUIDE COLLAR ARE OUT OF ALIGNMENT.

If the bushing is replaced/repaired at overhaul the following guidance is provided in our Standard Practices Manual 202A. It provides the same dimension as the new part/drawing.

E. Post-Installation Processing

CAUTION: DO NOT PERFORM POST INSTALLATION PROCEDURES UNTIL FULL BOND STRENGTH OF THE BUSHING INSTALLATION IS ACHIEVED, I.E., 24 HOURS AFTER INSTALLATION.

- (1) Machine the ID of the bushing in accordance with Figure 2-12.
- (2) Chamfer the bushing in accordance with Figure 2-12.
- (3) Examine the ID of the bushing for burring.
 - (a) Deburr the bushing if necessary.
- (4) Test the bushing in the guide lug with a press out force.
 - (a) Apply 225 pounds (1000 N) to the bushing.
- (5) The bushing in the guide lug must pass the pressure test.
 - (a) If the bushing fails the pressure test:
 - 1 Remove and discard the bushing.
 - 2 Clean the guide lug.
 - 3 Install a new bushing and inspect the bushing in accordance with the instructions in this section.



Machine and Chamfer the Bushing