

Date of Accident: July 6, 2023

Location: Burlington, CO

NTSB File No.: CEN23FA285

Aircraft: Piper PA-60-601P Aerostar

Registration No.: N100PB

Serial No.: 61P-0584-7963257 (Year of Manufacture 1978)

Operator: Per FAA Registry:
Doobie Air LLC
704 N. King St. Suite 500
Wilmington, DE 19801-3584

Written by: Les Doud - Air Safety Investigator

Report Date: August 9, 2023

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PROPELLER EXAMINATION REPORT

Date of Investigation: August 7-8, 2023

Location: Beegles Aircraft Service
635 Airport Road
Greeley, CO 80631

Propeller Model(s): HC-C3YR-2UF with FC8468B-8R blades

Representatives:

Les Doud	Hartzell Propeller Inc. ASI
Zane Brown	NTSB Investigator in Charge
Brian Rutt	NTSB Central Region ASI
Troy Helgeson	Lycoming ASI

ACCIDENT SYNOPSIS

The following is an excerpt from the NTSB preliminary report:

"On July 6, 2023, about 1330 mountain daylight time (MDT), a Piper PA-60-601P airplane, N100PB, was destroyed when it was involved in an accident near Burlington, Colorado. The pilot was fatally injured. The airplane was operated as a Title 14 Code of Federal Regulations Part 91 personal flight.

A search of radar and automatic dependent surveillance–broadcast (ADS-B) data sources did not reveal any track data for the flight. There were no witnesses to the accident. Video surveillance at the Kit Carson County Airport (ITR), Burlington, Colorado depicted the aircraft departing the runway about 1330 MDT.

No flight plan was found to be filed. Day instrument meteorological conditions (IMC) prevailed at the accident site.

The airplane impacted a fallow cornfield about 11.8 nautical miles (nm) southwest of the departure airport. A 350 ft long debris path, oriented on a 345° magnetic heading, preceded the location of the main wreckage. The airplane impacted the ground in a near wings level nose down attitude. The nose landing gear wheel and fork was found separated from the strut about 325 ft from the initial point of impact. The wing tips were found separated from both wings along the wreckage debris path on their respective sides.

The fuselage was fractured from the wing and the wing spars remained attached as one assembly. Flight control continuity could not be verified because the control push/pull tubes for the ailerons, elevators, and rudder exhibited extensive impact and fire damage. Both ailerons and flaps exhibited impact and fire damage. The hydraulic flap actuators were found retracted consistent with about 0° of flap extension. The flap control handle was not located during the investigation. Both elevators remained attached to the horizontal stabilizer and exhibited impact damage. The elevator trim tabs measured about 10° tab down. The rudder was found about 125ft from the empennage, its trim tab measuring about 4° tab left. The vertical stabilizer was fractured from the empennage and crushed.

The instrument panel sustained significant damage during the accident sequence and post impact fire. The altimeter indicated about 4,200 feet and was set to 30.13 inHg in the Kollsman window. The attitude indicator was extensively damaged and could not be tested. The internal gyro of the attitude indicator was found separated from its instrument case and exhibited

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evidence of rotational scoring. The airspeed indicator and backup course deviation indicator were not located. The Aspen primary flight display (PFD) was destroyed by impact and fire. The engine tachometer, manifold pressure gauge, combo oil pressure, temperature and fuel pressure gauges, and exhaust gas temperature gauge were also destroyed. The engine cylinder temperature gauge was found impact damaged with a needle impact mark at 100° C for the right engine, with no indications for the left engine. The pressurization controller was found set to about 12,500 ft (8,500 ft cabin pressure). The gyro pressure gauge was found damaged indicating 4.4 inHg with the right source inoperative.

The right magneto switch was found attached to its mounting location on the instrument panel and was in the OFF position. The left magneto switch was found intact but separated from its mounting location and was in the OFF position. The airplane's Garmin 430 and 530 panel-mounted GPS navigation/communication devices were recovered. The landing gear selector handle was found to be in the up and locked position, and the landing gear was found fully retracted at the accident site.

The right engine remained attached to its engine mounts and nacelle. The left engine was located among the debris field attached to its mount that fractured from its nacelle. The throttle quadrant was destroyed by impact and fire damage. Engine examinations will be conducted following recovery of the wreckage.

The right propeller separated from engine propeller shaft flange during impact. One blade separated from the hub and its leading edge was found lodged into the right engine's intercooler core. The other two blades remained attached to the hub but could be rotated in their housing by hand. The left propeller separated from engine propeller shaft flange during impact. One propeller blade separated from the hub, and the remaining two blades appeared to be in the normal range of operation. Two propeller blades exhibited bends in the aft direction, and the remaining blade appeared to be slightly bent aft. The propellers will be further examined at a later date.

Two fuel valves were located amongst the wreckage site, upon examination one fuel valve was in the CLOSED position and the other was in the OPEN position.

According to fueling documentation obtained from the ITR airport manager, the night before the flight, the pilot serviced the airplane with 113.4 gallons of 100 low-lead aviation fuel from the self-serve pumps at ITR."

SUMMARY AND ANALYSIS OF FINDINGS

The propellers were recovered from the crash scene to Beegles Aircraft Service in Greeley, CO for examination. The propellers were examined on August 7-8, 2023 to evaluate the blade damage and search for impact signatures that could offer estimates of blade angle and condition of operation prior to impact. This report documents the detailed findings of those examinations.

The aircraft impacted into flat, dry, hard-packed, farm field soil (Photo #1). Both propellers separated from their engines at the crankshaft flange during the impact sequence.

Photo #2 and #3 show a comparison left and right propeller blade bend and twist damage when looking from a leading edge and trailing edge perspective. The blade damage patterns and severity are similar for both propellers suggesting a somewhat symmetrical power condition. Internal impact signatures on both propellers indicated they were operating in a blade angle

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range between approximately 23-35°. As a point of reference, this propeller model at 23° blade angle is predicted to absorb 283 Hp at 5000 ft., ISA, 150 KTAS and 2575 RPM.

Other damage signatures that were consistent with power are chordwise/rotational scoring, compound bend and twist, bending opposite rotation and fractured pitch change mechanisms.

Photo #1 – Aircraft impact site and debris field
(Photo Courtesy of NTSB)



Photo #2 - Left vs. Right blade comparison (leading edge view)



Photo #3 - Left vs. Right blade comparison (trailing edge view)



CONCLUSIONS

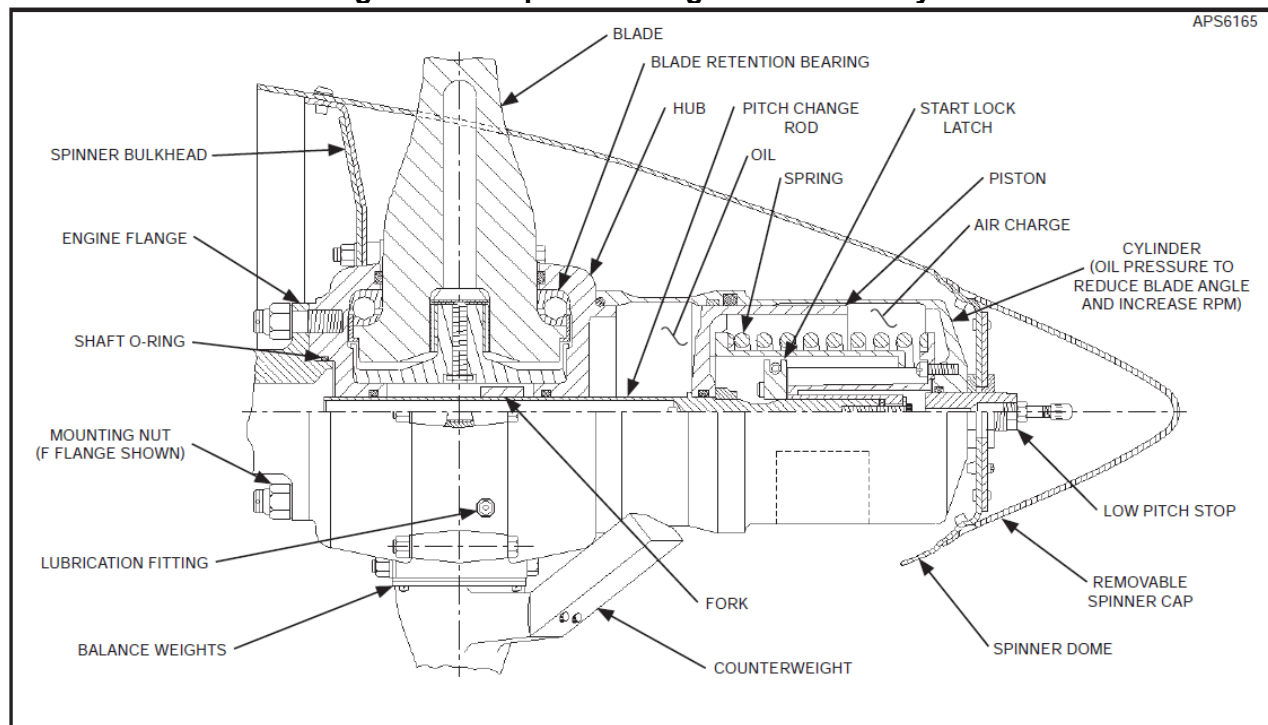
There were no discrepancies noted that would preclude or degrade normal operation on either propeller prior to impact. All damage was consistent with high impact forces. Both propellers exhibited damage consistent with a moderate aircraft impact angle into terrain while rotating with power in a normal blade angle range.

GENERAL INFORMATION

Propeller Description: The propellers examined are 78" diameter, 3-blade single-acting, hydraulically operated, constant speed model with feathering capability. Oil pressure from the propeller governor is used to move the blades to the low pitch (blade angle) direction. A spring, counterweights, and an air charge move the blades to the high pitch/feather direction in the absence of governor oil pressure. The propeller incorporates start locks to keep propeller blade angle low to minimize the starting torque. The blades and hub are of aluminum construction. Propeller rotation is clockwise as viewed from the rear. See Figure 1 for a cutaway sketch of the propeller model series labeling the major components.

Installation Data: Refer to Hartzell Propeller Installation Data Sheet No. 1870 (Data reference the 30-inch radius), TCDS A17WE for additional information.

Low Pitch:	14.0 ± 0.1 degrees
Start lock:	19.5 ± 1.5 degrees
Feather:	82.5 ± 1.0 degrees

Figure 1 – Propeller Configuration Cutaway

PROPELLER FACTUAL FINDINGS**Position:** LEFT**Propeller Model:** HC-C3YR-2UF with FC8468B-8R blades**Propeller Assembly Serial Number:** CK4333A**Service History:** The propeller logbooks were not available at this examination so service history, TSN/TSO and the last propeller service/inspection are unknown.

	<u>S/N</u>	<u>Date of Manufacture</u>	<u>TSN</u>	<u>TSO</u>
Hub/Factory	A31213A	5/30/1995	Unknown	Unknown
Blade L1	E63338	3/14/1980	"	"
Blade L2	E64605	3/14/1980	"	"
Blade L3	E64579	3/12/1980	"	"

Blade Orientation: The blades were identified L1-L2-L3 counterclockwise as viewed from the rear of the propeller. The assembly serial number was between the L1 and L2 blades.

As Received Condition: The propeller assembly impact-separated from the engine crankshaft flange during the impact sequence and was found partially buried in terrain near the main impact crater (Photo #4). One blade (L2) impact-separated from the propeller hub and was found lying on the terrain surface near the main propeller assembly. The hydraulic unit (cylinder, piston, feathering spring and pitch stops) also impact-separated and was found on the terrain surface further along the debris field. The spinner dome was impact-separated/torn from the assembly. All six mounting studs remained in the engine crankshaft flange. The propeller was presented for examination as shown in Photo #5. All three blades exhibited chordwise/rotational scorning and leading edge gouging. Blades L1 was bent aft, twisted toward low pitch with remarkable leading edge gouging, and had a remarkable impact mark in the shank trailing edge area where it exits the hub aperture. Blade L3 exhibited S-bending with chordwise/rotational scoring on the face side in the tip region. The blade retention pocket for blade L2 was fractured in the aft direction and the L2 bearing retention lip was partially fractured. The L2 pitch change knob was also fractured from the butt of the blade. All three counterweights remained attached to their respective blades.

Spinner: The spinner assembly was torn from the propeller assembly. Remnants of a spinner assembly were recovered but it wasn't determined if it was the left or right spinner (Photo #27). There were no discernable marks in the remaining spinner components that would suggest a blade angle at impact.

Engine/Propeller Mounting: The engine crankshaft flange remained attached to the crankshaft with all six propeller mounting studs attached (Photo #6). The crankshaft pilot bore lip was bent. The propeller hub mounting flange feet were fractured from the hub (Photo #7).

Propeller Cycling: Propeller cycling with air pressure was not possible due to impact damage.

Cylinder: The cylinder impact-separated from the propeller assembly and the threaded area was bent and partially torn (Photos #9 and #10). The piston, feathering spring and pitch stop

remained in the cylinder. No attempt was made to remove the feathering spring due to impact damage and safety concerns.

Piston: The piston appeared intact and remained in the cylinder.

Pitch Change Rod: The pitch change rod fractured in three places; just aft of the piston, on the forward side of the fork, and aft side of the fork. The segments forward and aft of the fork were bent and jammed in the hub bores/bushings.

Fork: The fork was found loose in the hub. The pitch change rod had fractured from the fork on both the forward and aft sides. The fork was intact with no remarkable fractures seen in the slots/tangs. There were pitch change knob block marks in all three slots representative of blade angles in normal range of operation (Photo #8).

Spring/Spring Guides: The feathering spring and guides were not observed. They remained loaded in the hydraulic unit/cylinder and were not removed due to damage and safety concerns.

Pitch Stops:

Low Pitch Stop:	The low pitch stop assembly was intact with the air valve and cap still attached. The face of the low pitch stop exhibited contact damage from the cap screw (Photo #11). The pitch stop stack appeared intact and secure when viewed through the low pitch stop hole (Photo #12)
Feather Stop:	The hydraulic unit was not disassembled due to damage and safety concerns. The feather stop washer appeared intact (Photo #12).
Start Lock:	The forward pitch change rod with the pitch stop stack appeared loaded on the start lock assembly and sleeve when viewed through the low pitch stop hole (Photo #12).

Hub Assembly: The hub assembly was fractured at the mounting flange, the L2 blade retention pocket and the cylinder mounting boss were fractured (Photos #13 through #16). All of the hub thru-bolts were present but those around the L2 retention arm were bent (Photos #14 and #15). The preload shelves and webs of all three blades were marred and/or fractured. The bearing retention radius for L2 on the forward hub was fractured. There was a crack in the aft hub wall between the L2 and L3.

Preload Plates: For this propeller model, when the blade knob is aligned with the hub parting line, the blade angle at the reference station is approximately 48.5° (knob $12^\circ + 36^\circ$ constant + 3-blade delta of $0.5^\circ = 48.5^\circ$). All three preload plate lips were sheared and smashed and had impact damage on the aft/face side where the plate rests against the aft hub web. All three plates had fork impact marks in the lower ($<48^\circ$) blade angle range of normal operation (See Table below and Photo #17).

Propeller Governor: Model No.: F-6-35Z, Serial Number: C39T (DOM 8/1/1978)
The left propeller governor remained attached to the engine. It was removed during this examination. The gasket/screen was clear of debris (Photo #24). The pump shaft rotated freely and smoothly. The control arm rotated from the high RPM stop to the feather stop freely and smoothly.

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Preload Plate	Condition
L1	The forward/low pitch end of the knob slot was fractured by the remnants of the pitch change knob forcefully rotated under the plate. There were pitch change knob marks in the slot at 35° and 14° forward of the split line. There was a circular, fork bumper mark at 0.49" forward of the split line.
L2	The plate was distorted and aft sidewall of the plate was fracture-separated. The forward/low pitch end of the knob slot was fractured by the remnants of the pitch change knob forcefully rotated under the plate. There were pitch change knob marks in the slot at 35° and 20° forward of the split line.
L3	There was a circular, fork bumper mark at 0.41" forward of the split line.

Propeller Blade Properties: See Photos #18 through #23.

Blade # L1

Camber side	Chordwise/rotational scoring
Face side	Chordwise/rotational abrasion and scoring
Bend	Aft and opposite rotation
Twist	Toward low pitch
Lead edge damage	Nicks and gouges (Photo #22)
Trail edge damage	Not remarkable
Knob condition	Fractured (Photo #18)
Counterweight	Intact
Blade bearings	Intact
Butt/shank impact marks	Hub aperture contact mark in the trailing edge quadrant near the Teflon rub strip area.
De-Ice boot	Cut/torn

Blade # L2 – Impact separated from the assembly

Camber side	Chordwise/rotational scoring
Face side	Spanwise abrasion near shank
Bend	Slightly aft
Twist	Not remarkable
Lead edge damage	Nicks
Trail edge damage	Not remarkable
Knob condition	Fractured (Photo #18)
Counterweight	Intact but displaced from mounting boss
Blade bearings	Some of the bearing races and balls separated from assembly when the blade separated. One bearing race fragment remained in the hub and exhibited a fracture with ball imprints consistent with overload. (Photo #19)
Butt/shank impact marks	Bearing race retention lip sheared. Hub aperture contact mark/dent on the face side near the Teflon rub strip area.
De-Ice boot	Nicks and cuts along the leading edge

Blade # L3

Camber side	Chordwise/rotational scoring along leading edge
Face side	Chordwise/rotational scoring near tip
Bend	S-bending (forward at tip, aft in mid-blade), opposite rotation
Twist	Not remarkable
Lead edge damage	Nicks and gouges near tip
Trail edge damage	Nicks and abrasion
Knob condition	Intact
Counterweight	Intact
Blade bearings	Intact
Butt/shank impact marks	Hub aperture contact mark in face/trailing edge quadrant
De-Ice boot	Appears undamaged

Photo #4 - Left propeller in-situ
(Photo provided by NTSB)



Photo #5 - Left propeller as presented for examination



Photo #6 - Left engine crankshaft flange



Photo #7 - Left propeller hub mounting flange

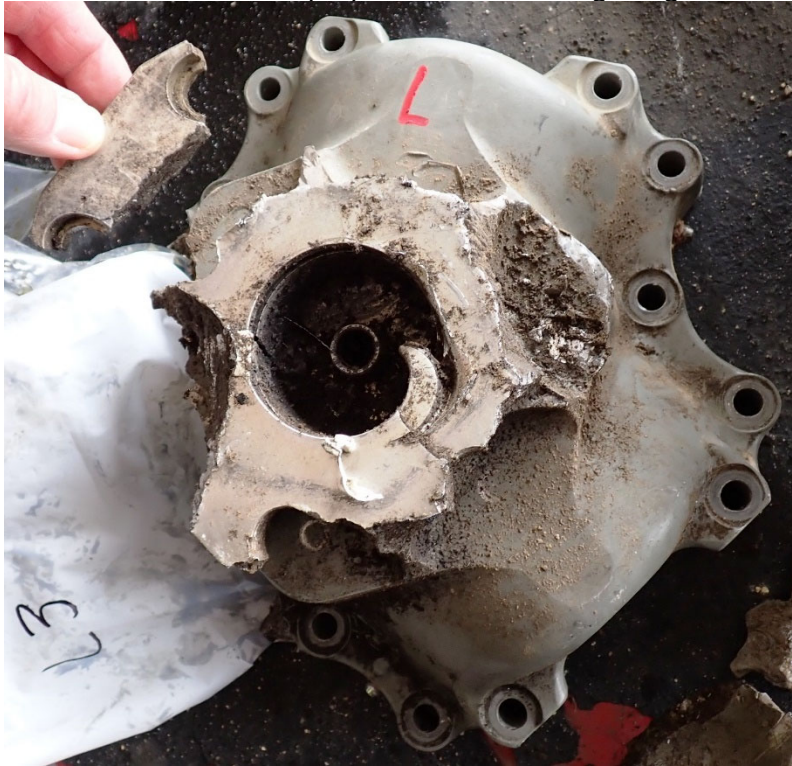


Photo #8 - Left fork slots



Photo #9 - Left propeller hydraulic unit



Photo #10 - Left piston remaining in cylinder



Photo #11 - Left propeller low pitch stop impact mark



Photo #12 - Left propeller pitch stop stack intact and near the start lock



Photo #13 - L2 blade retention pocket fractured



Photo #14 - Left propeller forward hub half – external view



Photo #15 - Left propeller forward hub half – internal view

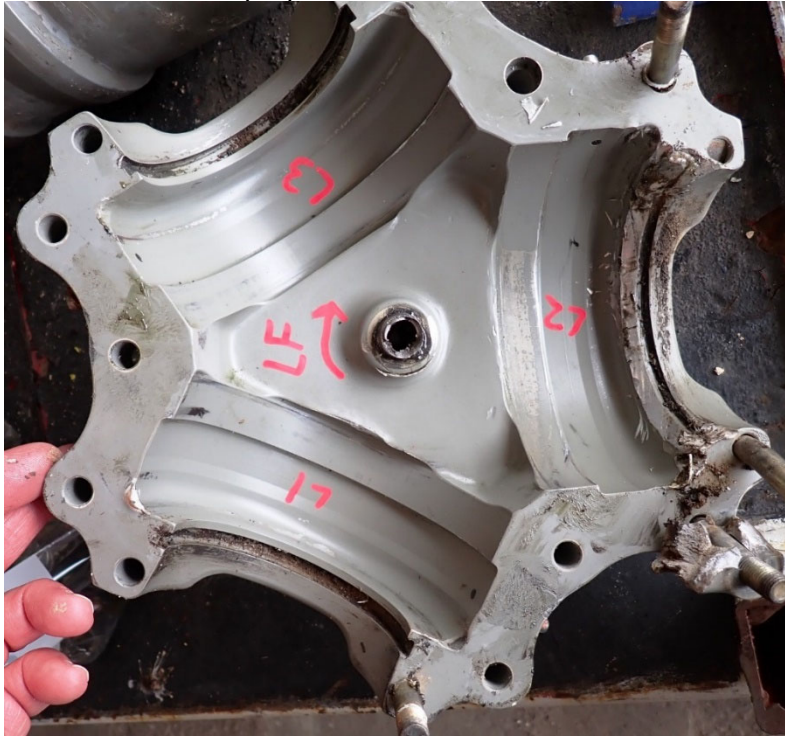


Photo #16 - Left propeller aft hub – internal view



Photo #17 - Left preload plates

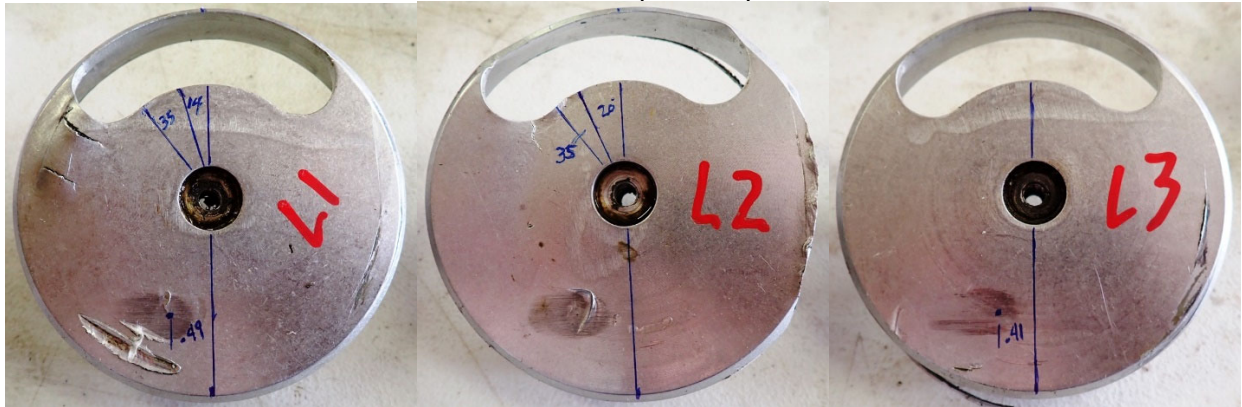


Photo #18 - Left blade pitch change blocks (L1 and L2 knobs fractured)



Photo #19 - Left blade retention bearing race fracture with ball bearing marks



Photo #20 - Left propeller blades camber side (L1-L2-L3 left-to-right)



Photo #21 - Left propeller blades face side



Photo #22 - L1 leading edge gouging



Photo #23 - Left blades (L2-L3-L1 left-to-right) trailing edge view



Photo #24 - Left propeller governor and gasket



Position: RIGHT

Propeller Model: HC-C3YR-2UF with FC8468B-8R blades

Propeller Assembly Serial Number: CK4332A

Service History: The propeller logbooks were not available at this examination so service history, TSN/TSO and the last propeller service/inspection are unknown. Blade R2 was manufactured as a -6R model and was apparently modified to a -8R model sometime during its service life.

	<u>S/N</u>	<u>Date of Manufacture</u>	<u>TSN</u>	<u>TSO</u>
Hub/Factory	A31206A	5/30/1995	Unknown	Unknown
Blade R1	C55366	2/22/1974	"	"
Blade R2	C56734	5/14/1974	"	"
Blade R3	E4051	11/3/1978	"	"

Blade Orientation: The blades were arbitrarily identified R1-R2-R3 counterclockwise as viewed from the rear of the propeller. The hub serial number was between the R1 and R2 blades.

As Received Condition: The propeller assembly impact-separated from the engine crankshaft flange during the impact sequence and was found on top of terrain near the main impact crater (Photo #25). One blade (R1) impact-separated from the propeller hub, impaled the turbo intercooler (Photo #28) and was found near the main propeller assembly. The hydraulic unit (cylinder, piston, feathering spring and pitch stops) also impact-separated and was either not recovered or presented for examination. The spinner dome was impact-separated/torn from the assembly. Five mounting studs with nuts attached remained in the engine crankshaft flange and the sixth stud was fractured. The propeller was presented for examination as shown in Photo #26. All three blades exhibited chordwise/rotational scorning and leading edge nicks. Blades R1 and R3 were bent aft, bent opposite rotation and twisted toward low pitch. Blade R2 did not exhibit any remarkable bend or twist. The blade retention pocket for blade R1 was fractured in the aft direction. The aft hub was fractured between R2 and R1 retention pockets. The counterweight for R2 impact-separated and the counterweights for R1 and R3 remained attached to their respective blades.

Spinner: The spinner assembly was torn from the propeller assembly. Remnants of a spinner assembly were recovered but it wasn't determined if it was the left or right spinner (Photo #27). There were no discernable marks in the remaining spinner components that would suggest a blade angle at impact.

Engine/Propeller Mounting: The engine crankshaft flange remained attached to the crankshaft with all portions of all six propeller mounting studs attached (Photo #29). The crankshaft pilot bore lip was bent and packed with earthen debris. The propeller hub mounting flange feet were fractured from the hub (Photo #30).

Propeller Cycling: Propeller cycling with air pressure was not possible due to impact damage.

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Hydraulic Unit: The hydraulic unit consisting of the cylinder, piston, feathering spring, pitch stops and start lock impact-separated from the assembly and was not recovered or presented for examination.

Pitch Change Rod: The pitch change rod fractured in three places; just aft of the piston, on the forward side of the fork, and aft side of the fork. The segments forward and aft of the fork were bent and jammed in the hub bores/bushings.

Fork: The fork was found loose in the hub. The pitch change rod had fractured from the fork on both the forward and aft sides. The fork was intact with no remarkable fractures seen in the slots/tangs. There were pitch change knob block marks in all three slots representative of blade angles in normal range of operation (Photo #31).

Hub Assembly: The hub assembly was fractured at the mounting flange. The R1 blade retention pocket and the cylinder mounting boss were fractured (Photos #32 through #35). The hub was partially packed with dirt and had evidence of being over-serviced with grease. All of the hub thru-bolts were present but those around the R1 retention arm were bent or fractured (Photos #33 and #34). The preload plate shelves and webs of all three blades were marred and/or fractured. The bearing retention radius for R1 on the forward hub was fractured. There was a fracture in the aft hub wall that spanned between the R1 and R2 blade retention pockets.

Preload Plates: For this propeller model, when the blade knob is aligned with the hub parting line, the blade angle at the reference station is approximately 48.5° (knob $12^\circ + 36^\circ$ constant + 3-blade delta of $0.5^\circ = 48.5^\circ$). All three preload plate lips were sheared and smashed and had impact damage on the aft/face side where the plate rests against the aft hub web. All three plates had fork impact marks in the lower ($<48^\circ$) blade angle range of normal operation (Photo #36).

Preload Plate	Condition
R1	The plate was fractured into two major pieces (Photo #). There were pitch change knob marks in the slot at 23° forward of the split line.
R2	The plate was distorted and aft sidewall of the plate was fracture-separated. The forward/low pitch end of the knob slot was fractured by the remnants of the pitch change knob forcefully rotated under the plate. There was a pitch change knob mark in the slot at 43° forward of the split line.
R3	There were pitch change knob marks in the slot at 25° and 11° forward of the split line. There was a circular, fork bumper mark at 0.45" forward of the split line.

Propeller Governor: The right propeller governor impact-separated from the engine and was not presented for examination.

Propeller Blade Properties: See Photos #37 through #42

Blade # R1- Impact separated from the assembly and impaled the turbo intercooler (Photo #28)

Camber side	Chordwise/rotational scoring (Photo #41)
Face side	Spanwise scoring at tip, paint blistering in the mid-blade area
Bend	Aft and opposite rotation
Twist	Towards low pitch
Lead edge damage	Nicks, localized bend towards low pitch at tip
Trail edge damage	Not remarkable
Knob condition	Fractured (Photo #37)
Counterweight	Intact
Blade bearings	Some of the bearing races and balls separated from assembly when the blade separated. One bearing race fragment remained in the hub and exhibited a fracture with ball imprints consistent with overload. (Photo #38)
Butt/shank impact marks	Face-side impact marks and hub aperture impact mark near trailing edge. The bearing retention lip was partially sheared.
De-Ice boot	Cut/torn near inboard end

Blade # R2

Camber side	Chordwise/rotational scoring (Photo #41)
Face side	Radom scoring, spanwise scoring in mid-blade area
Bend	Not remarkable
Twist	Not remarkable
Lead edge damage	Nicks
Trail edge damage	Localized bend at tip
Knob condition	Fractured (Photo #37)
Counterweight	Impact separated (bolts pulled), not recovered
Blade bearings	Intact
Butt/shank impact marks	Hub contact marks on face side/trailing edge quadrant
De-Ice boot	Torn along the leading edge

Blade # R3

Camber side	Chordwise/rotational scoring (Photo #41)
Face side	Spanwise scoring
Bend	Aft and opposite rotation
Twist	Toward low pitch
Lead edge damage	Nicks
Trail edge damage	Small, localized bends
Knob condition	Fractured (Photo #37)
Counterweight	Intact
Blade bearings	Intact
Butt/shank impact marks	Hub contact marks on face/trailing edge quadrant, and face/leading edge quadrant
De-Ice boot	Abraded along leading edge outboard area

Photo #25 - Right propeller in-situ
(Photo provided by NTSB)



Photo #26 - Right propeller as-presented



Photo #27 - Propeller spinner assembly remnants



Photo #28 - Blade R1 impaled the turbo intercooler



Photo #29 - Right engine crankshaft flange



Photo #30 - Right propeller hub mounting flange



Photo #31 - Right fork slots

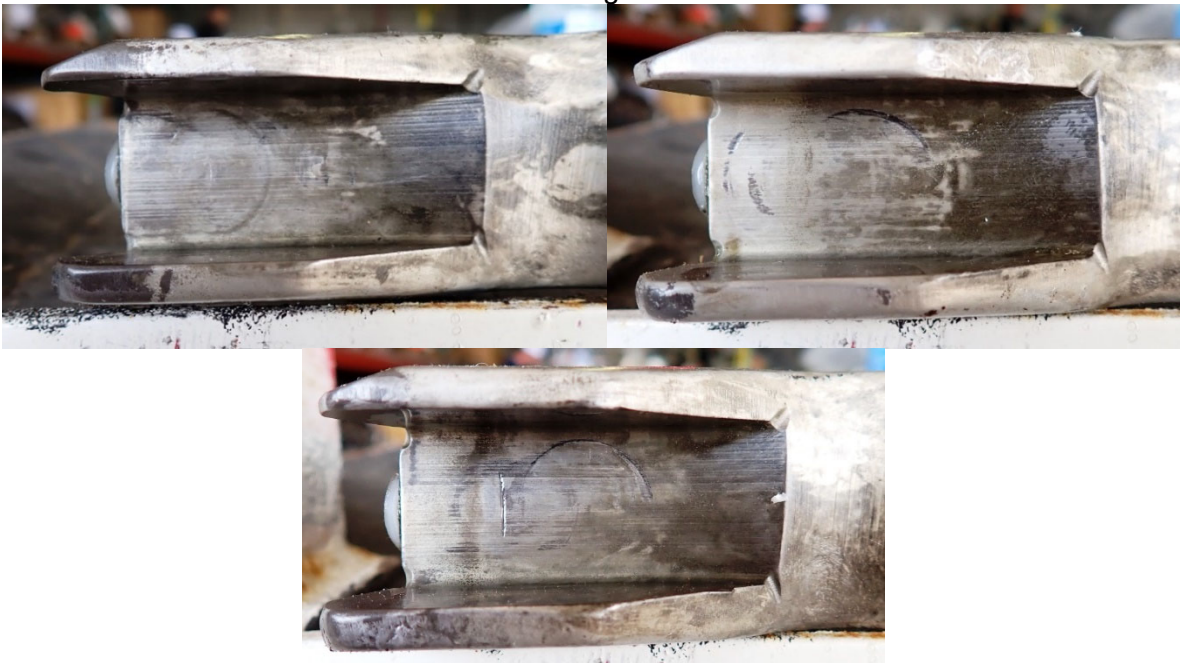


Photo #32 - R1 blade retention arm fractured



Photo #33 - Right propeller forward hub half – external view



Photo #34 - Right propeller forward hub half – internal view



Photo #35 - Right propeller aft hub – internal view



Photo #36 - Right preload plates



Photo #37 - Right blade pitch change blocks (R1 and R2 knobs fractured)



Photo #38 - Right blade retention bearing race fracture with ball bearing marks



Photo #39 - Right propeller blades camber side (R1-R2-R3 left-to-right)



Photo #40 - Right propeller blades face side



Photo #41 - Right blades camber-side scoring



Photo #42 - Right blades (R2-R3-R1 left-to-right) trailing edge view

