

National Transportation Safety Board

Office of Aviation Safety

Washington, DC 20594



ERA22FA010

WRECKAGE EXAMINATION

November 17, 2023

A. ACCIDENT

Location: Cornwall, New York
Date: October 10, 2021
Time: 1357 eastern daylight time
1757 UTC
Helicopter: N637HP, Robinson R44 II

B. WRECKAGE EXAMINATION

IIC	Doug Brazy NTSB Ashburn, Virginia
Party Coordinator	Chez Fogel FAA Teterboro, New Jersey
Group Member	Thom Webster Robinson Helicopter Corporation Torrence, California
Group Member	Mike Childers Lycoming Engines Williamsport, Pennsylvania

C. DETAILS OF THE EXAMINATION

1.0 Accident Site

The helicopter came to rest in a hilly wooded area. The primary wreckage path was about 110 ft long, oriented on a heading of about 155° true (168° magnetic). It began with a section of damaged trees at the base of which was the tail rotor gearbox (with blades attached) and ended at the main wreckage. The main wreckage came to rest against a fallen tree about 60 feet south of the first point of ground impact (impact crater) which was a two-foot-deep crater in the soft dirt, approximately 5 feet wide and 9-10 feet long. The crater had portions of several components associated with the belly of the fuselage, landing gear, and lower part of the engine. Located in the immediate area around crater were the empennage, fuselage pieces, tail rotor driveshaft, landing gear components, and engine components. There were no

indications of fire. Another damaged tree with broken branches on the ground was found about 40 ft northeast of the start of the wreckage path.



Figure 1 - Accident Site

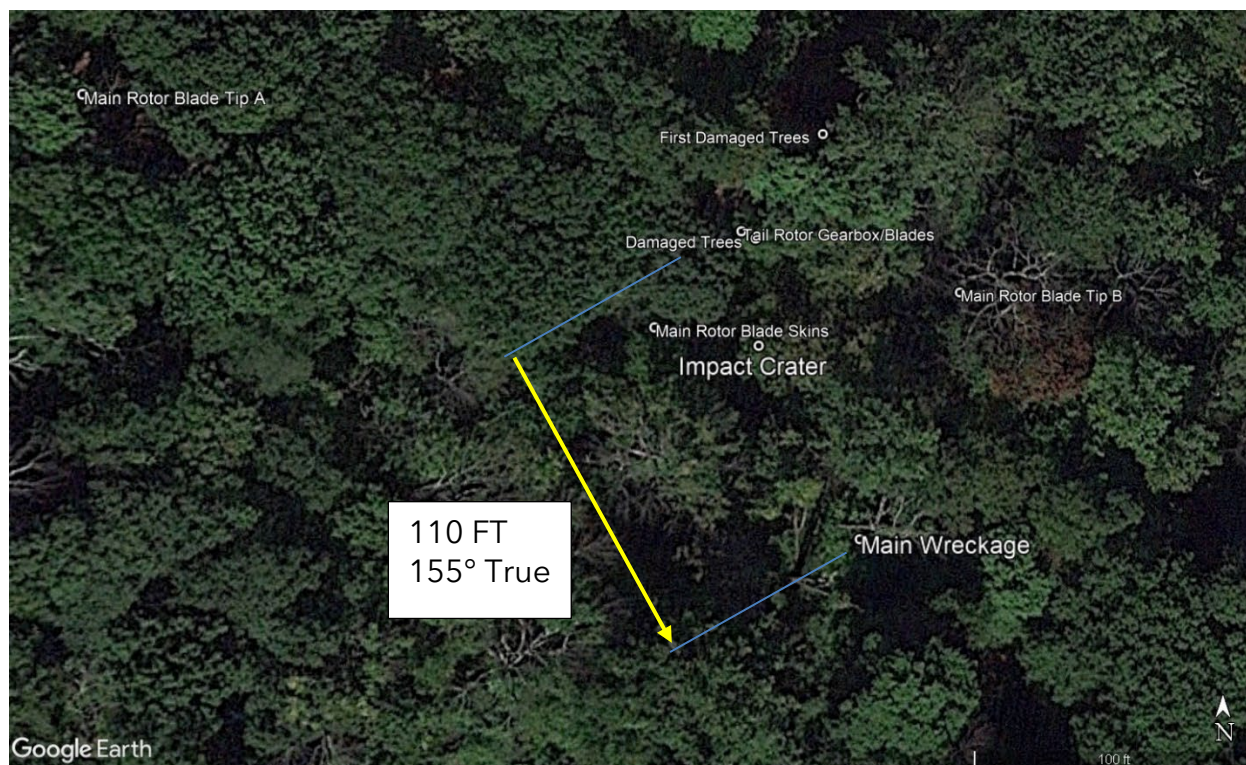


Figure 2 - Wreckage Diagram

The location of some key components are listed in the table below.

<u>Item</u>	<u>Description</u>	<u>Latitude</u>	<u>Longitude</u>	<u>Elevation (feet)</u>
1	Impact Crater	41.427260°	-73.985560°	253
2	Empennage	41.427279°	-73.985567°	253
3	Tail Rotor Driveshaft	41.427269°	-73.985615°	256
4	Right Skid w/Float	41.427223°	-73.985565°	254
5	Engine Cowling, Strut	41.427220°	-73.985548°	253
6	Left Skid w/Float	41.427226°	-73.985508°	251
7	Main Rotor Blade Skins	41.427275°	-73.985682°	260
8	Tail Rotor Gearbox w/Blades	41.427360°	-73.985580°	253
9a	First Damaged Trees	41.42745°	-73.98548°	265
9b	Damaged Tree Tops	41.427354°	-73.985563°	252
10	Section of Tail Cone w/Guard	41.427460°	-73.985600°	251
11	Section of Tail Cone w/Decal	41.427440°	-73.985740°	259

12	Main Rotor Blade Tip Section A	41.427460°	-73.986300°	279
13	Float Bottle, Strut	41.427069°	-73.985386°	248
14	Main Wreckage	41.427090°	-73.985440°	250
15	Main Rotor Blade Tip Section B	41.42731°	-73.98531°	261

An area to the left of the main wreckage exhibited blight of the foliage.

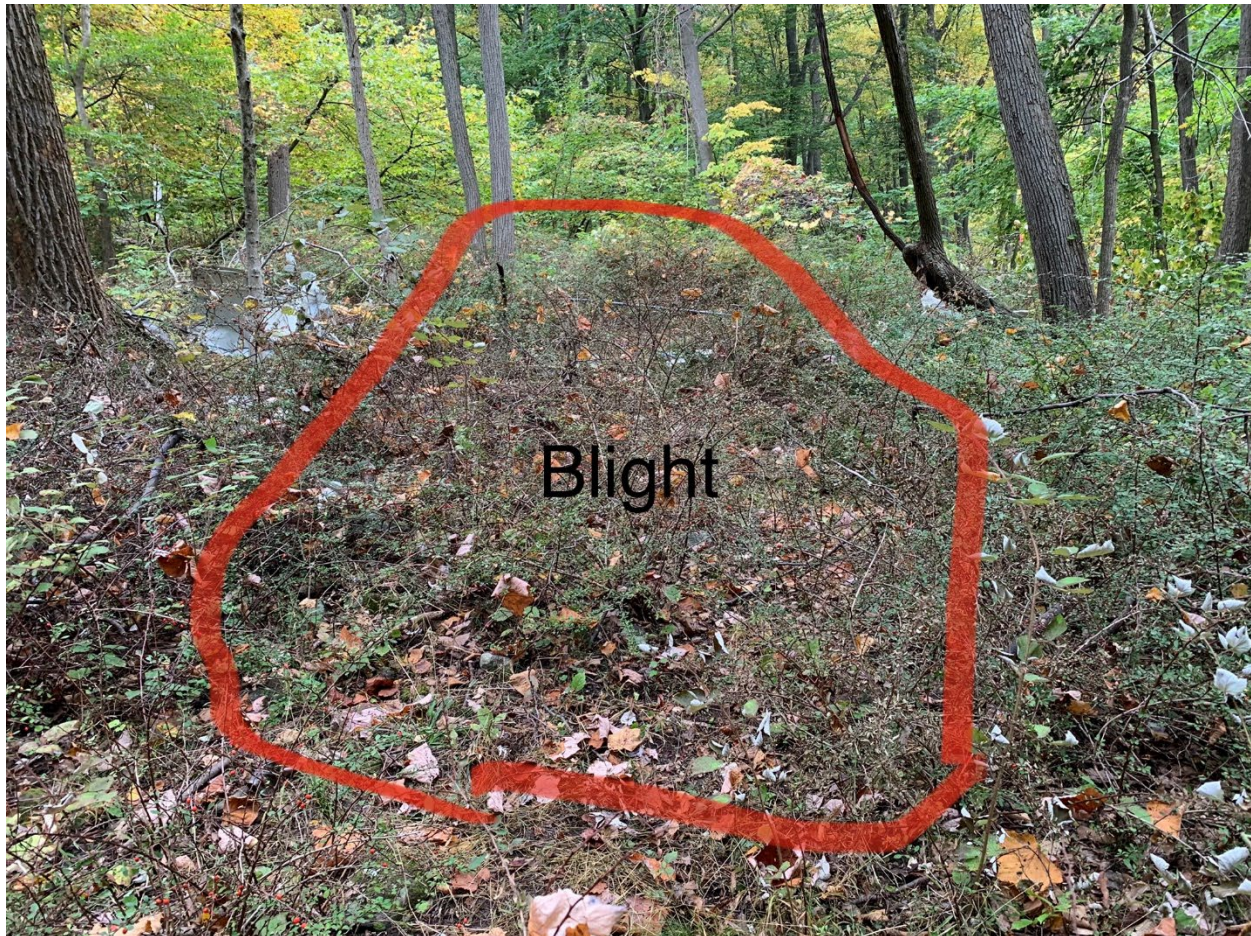


Figure 3 - Foliage Blight

2.0 Airframe Examination

The airframe sustained severe impact damage. The cabin structure and fuselage cowlings were crushed from the nose to the rear seats. All 4 seats were separated from the structure. The upper and lower frame tubes were bent, deformed, and had several disconnects including a complete separation of the frame tubes around the main rotor gearbox. Remnants of all four doors were found in the debris path or with the main

wreckage. The vertical firewall was crushed upward, and the horizontal firewall was severely deformed with the section around the main rotor gearbox torn away. One of the attachments for the tailcone was pulled away from the upper frame mount, the others remained secure but slightly deformed. Tailcone bays 5 and 6 were crushed on the right side with a large amount of brown transfer marks appearing to be tree residue. The lower portion of tailcone bays 5 and 6 were torn away along with the aft portion of bay 6. Small sections of tailcone bays 5, 6 and 7 were recovered in the debris field. The aft bulkhead remained attached to bay 7 although the empennage mount was disconnected. The empennage sustained impact damage to the leading edge of all three stabilizers.



Figure 4 - Front Right Side of Fuselage



Figure 5 - Left Side of Fuselage



Figure 6 - Damage to Tailcone Bays 5 and 6



Figure 7 - Empennage

3.0 Cockpit

The upper and lower consoles along with the avionics panel were damaged and components separated. Both front seat belts were unbuckled, the aft right seat belt was buckled, and the aft left seat belt condition could not be determined. Damaged remnants of several tablet devices were found in the debris field.



Figure 8 - Upper Instrument Panel



Figure 9 - Lower Instrument Panel

Table of As Found Instrument Indications and Switch Positions:

<u>Instruments:</u>		<u>Switches:</u>	
Vertical Speed	1800fpm Ascent (damaged)	NAV Lights	Damaged
Airspeed	140 Knots	Strobe	Damaged
Engine/Rotor Tach.	Lower Pins	Clutch	Damaged
Altimeter	840'@30.16	Clutch Guard	Damaged
Manifold Pressure	Damaged	Alternator	Damaged
CAT	N/A	Master	Damaged
OAT	Inoperable	Ignition (Magnetos Switch)	R
Amps	Damaged	Landing Light	On
Oil Pressure	Lower Pin	Pitot Heat	On
Oil Temperature	Lower Pin	Map Light	Damaged
Cyl. Head Temp.	350°	Governor	On
Main Fuel	Lower Pin	Air Conditioner	Damaged
Aux Fuel	Lower Pin	Intercom	Inoperable
Dimmer/Panel Lights	Damaged	Hydraulics	Damaged
Clock (electronic)	Inoperable		
		<u>Control Knobs:</u>	
Hour Meter	867.3 Hours (damaged)	Cabin Air	Closed
		Mixture	Full Rich
Transponder	Damaged	Mixture Guard	Damaged
Comm/Nav Radios	Damaged	Pop-Out Float Lever	Locked
Attitude Indicator (electronic, powered on via internal backup battery)	Functional	Cabin Heat Valve	Full On
GPS	Damaged	Cyclic Friction	Off
		Collective Friction	Damaged
		Fuel Valve	Damaged



Figure 10 - Circuit Breaker Panel

All circuit breakers were found IN/DOWN except:

AUX/PWR and HYD were found partially UP/OUT

D GYRO/HORIZ, EFIS and AVIONICS FAN were found UP/OUT

The warning lamps on the upper and lower instrument panels were removed and their filaments were examined with a magnifying glass. Lamps that were too damaged to be examined are denoted as "damaged". Filaments that appeared normal with no stretching observed are denoted as "Tight Coil".

Table of Warning Light Filament Conditions:

<u>Description</u>	<u>Tight Coil</u>		<u>Stretched Coil</u>
Low Rotor RPM			X
Low Fuel	X		
TR Chip	X		
Starter On	X		
MR Chip	X		
MR Temp	X		
Clutch	X		
Alternator		Damaged	
Oil Pressure - Engine		Damaged	
Governor OFF		Damaged	
Rotor Brake		Damaged	
Carbon Monoxide	X		
Engine Fire	X		
Fuel Filter		Damaged	
Aux Fuel Pump		Damaged	

The low rotor RPM light bulb was sent to the NTSB Materials Laboratory for further examination. The filament was found intact and demonstrated hot filament stretching.

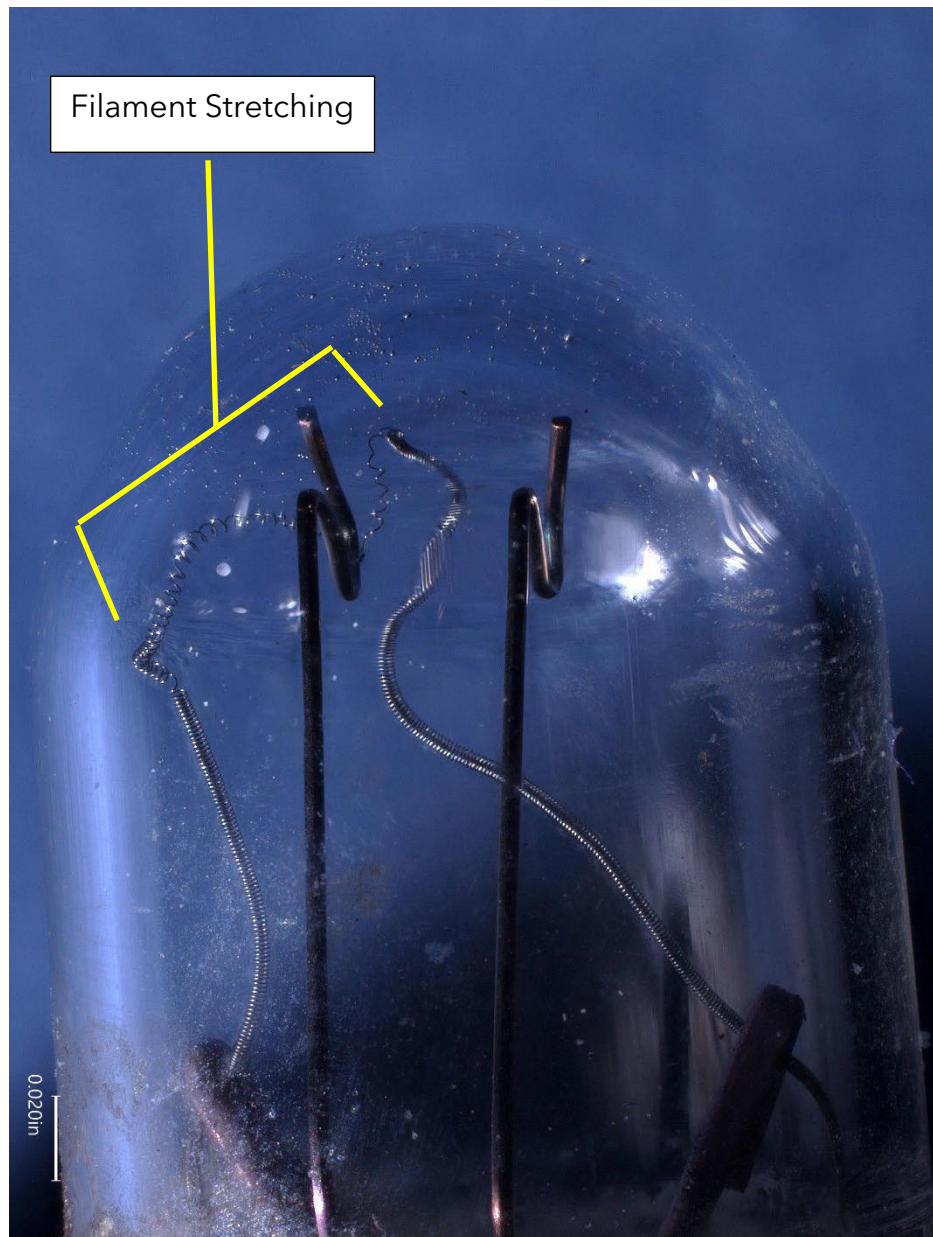


Figure 11 - Low Rotor RPM Lamp - Filament Stretching - NTSB Laboratory Microscope Photograph

The low rotor RPM lamp illuminates (and a horn sounds) when the main rotor speed is below 97%. The light and horn are disabled when the collective is fully down.

4.0 Airframe Fuel System

The main fuel tank remained partially secure to the airframe. The shell was dented and deformed. The bladder was compromised at the forward bulkhead and only a small amount of fuel remained in one corner. The fuel was blue in color and had the aroma of 100LL aviation fuel. The filler neck was pulled off of the shell. The filler cap remained secure on the neck. The finger strainer was clear.

The auxiliary fuel tank was separated from the airframe and tethered by the aft right seat belt. The shell was compromised in several places but the bladder had only one small tear. A trace amount of fuel was drained from the auxiliary tank, it was blue in color and had the aroma of 100LL aviation fuel. The filler cap remained secure on the filler neck. The finger strainer was clear. The outlet fitting was fractured.

The vent hoses remained secure to the fuel tanks with the exception of the crossover hose which was separated from the auxiliary vent tube. The hoses and the upper aluminum vent tubes were clear when blown through with air. The rollover valves operated properly.

The fuel shut-off valve was separated from the firewall and the fuel lines. It was in the open position.

The gascolator was separated from the auxiliary fuel pump and both were separated from the firewall. The gascolator bowl was dented and cracked. The bowl retaining ring had to be cut for removal. The gascolator screen and bowl had a small amount of debris inside, the screen was unobstructed, no fuel was present.



Figure 12 - Main Fuel Tank Shell



Figure 13 - Main Fuel Tank Bladder

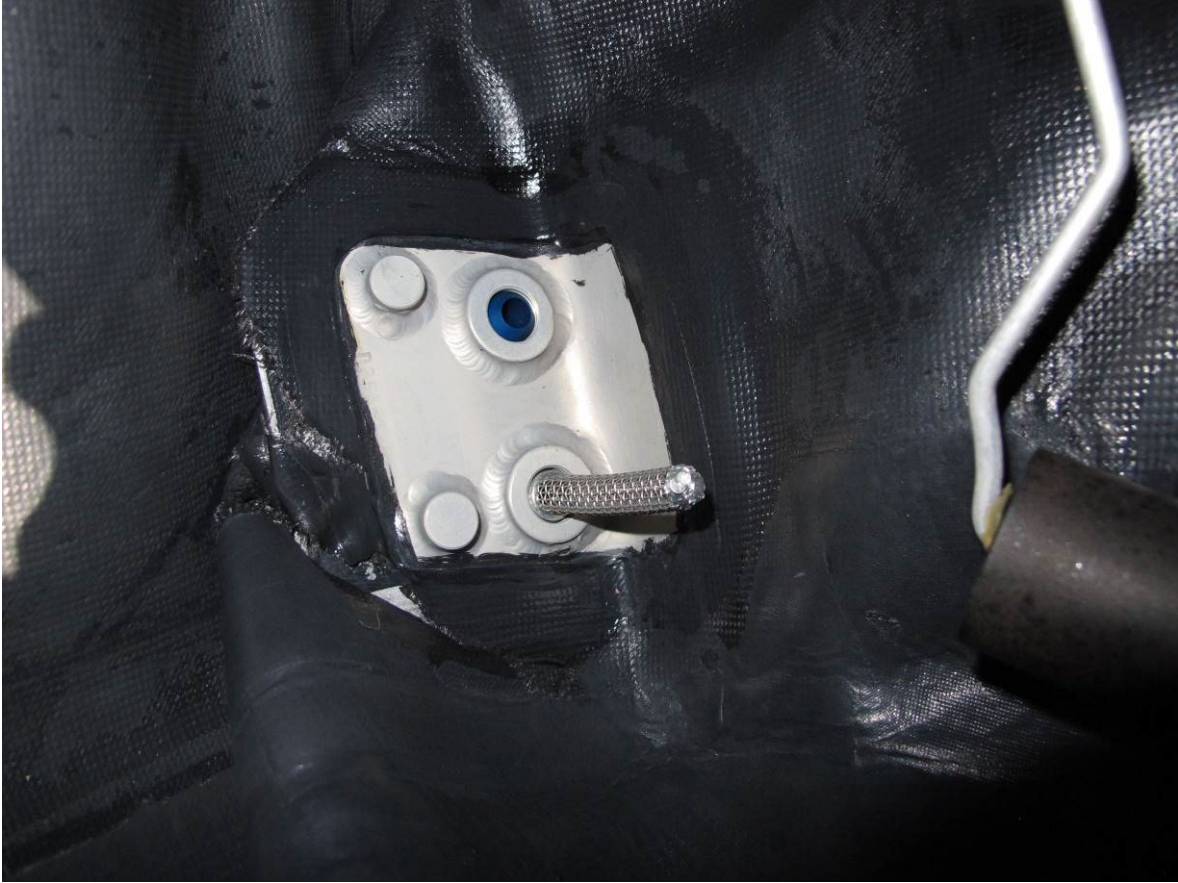


Figure 14 - Main Fuel Tank Finger Strainer



Figure 15 - Auxiliary Fuel Tank Shell



Figure 16 - Fuel Shut-off Valve



Figure 17 - Gascolator



Figure 18 - Gascolator - Top (and Screen) Removed



Figure 19 - Auxiliary (electric) Fuel Pump and Outlet Hose

5.0 Flight Controls

Flight control continuity could not be confirmed due to impact damage, and some system portions were not located. All control linkage ends remained attached. Nearly all control tubes were fractured in one or more locations consistent with overload. All three hydraulic servos moved smoothly in both directions when the input control tubes were moved by hand. The tail rotor pitch change slider was free to slide along the tail rotor gearbox output shaft. Both main rotor pitch change links were fracture separated at their upper rod ends. One link was also fracture separated at its lower end, and the link was found in a puncture hole in the cabin ceiling.

The pilot's cyclic grip was separated from the cyclic crossbar. The collective control was separated from the structure along with the collective friction slider which appeared to be in a collective full up position. The friction knob was positioned beyond its normal travel. The pilot's (right-side) tail rotor pedals were positioned with the left pedal forward. The copilot's (left-side) removeable controls were not installed and were recovered within the debris field.



Figure 20 - Cyclic Control



Figure 21 - Cyclic Control Grip



Figure 22 - Collective Control



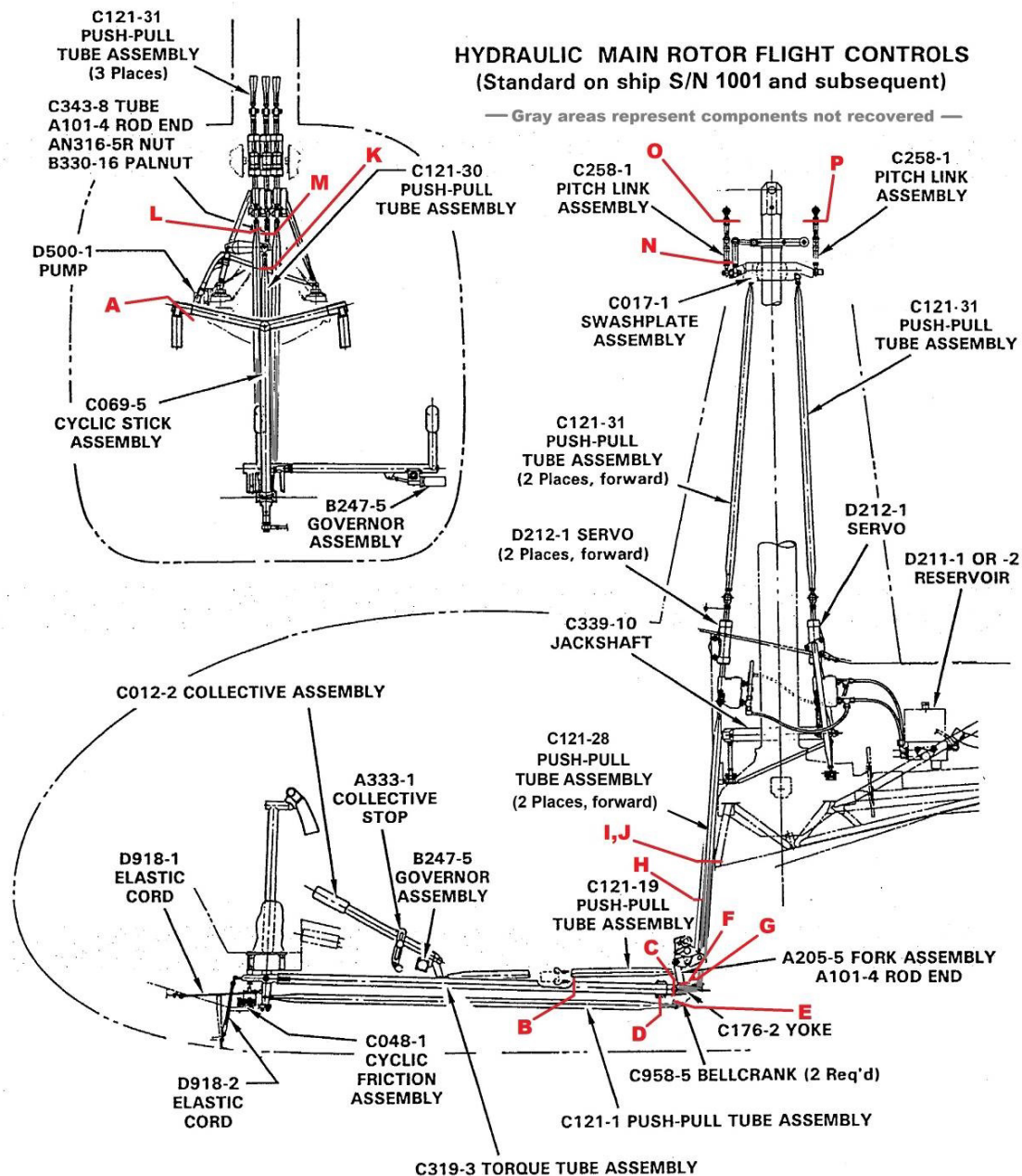
Figure 23 - Pilot's Side Anti-Torque (Tail Rotor) Pedals



Figure 24 - Fractures at Upper ends of the Two Main Rotor Pitch Change Links



Figure 25 - Tail Rotor Pitch Change Links



TAIL ROTOR CONTROL SYSTEM

N637HP

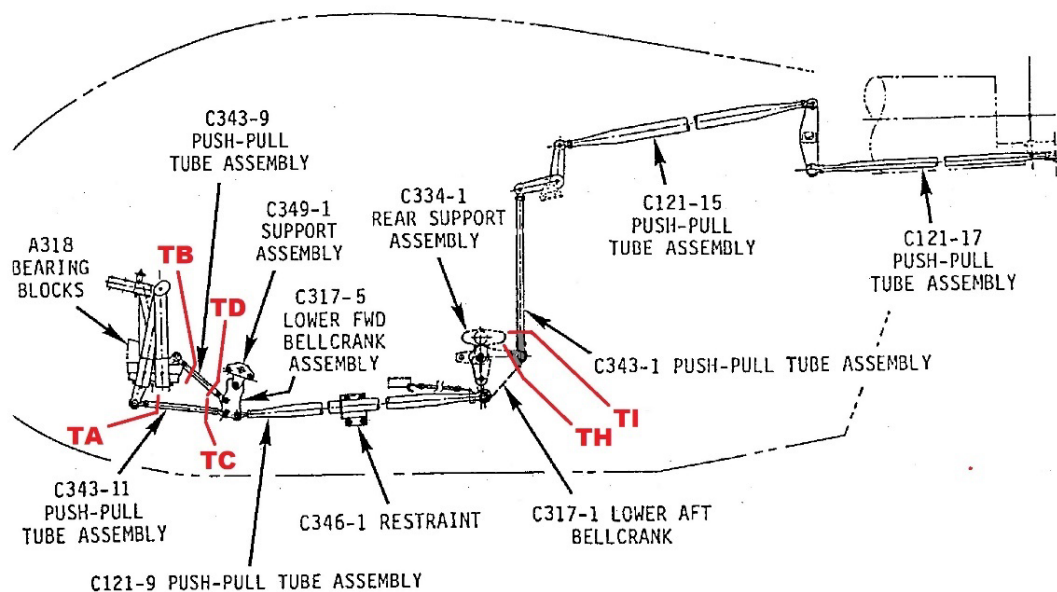
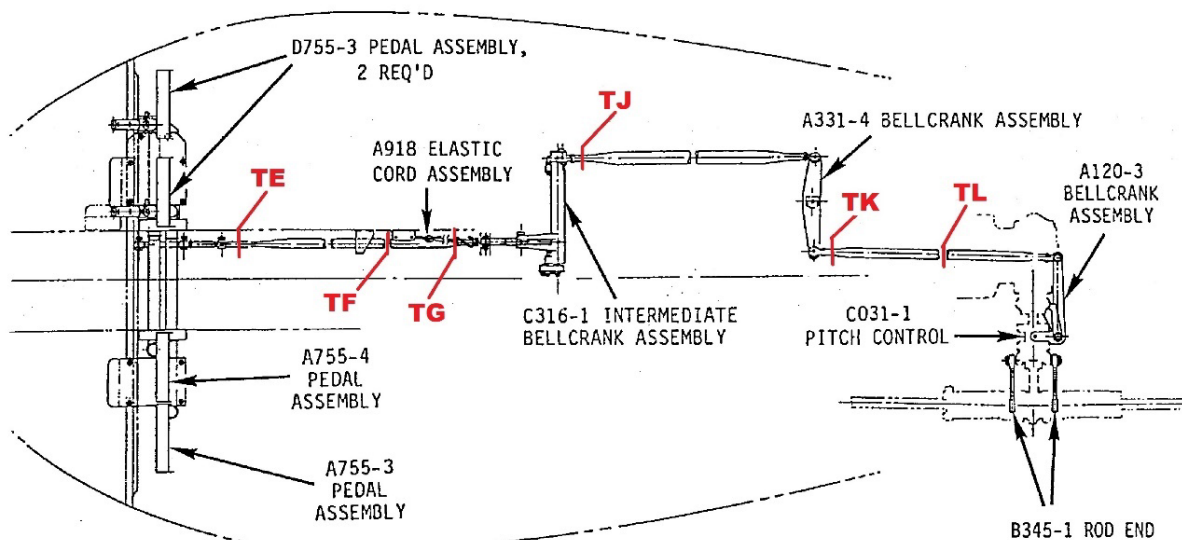


Figure 27 - Diagram of Fracture Locations in the Tail Rotor Control System

6.0 Drive System and Rotor Blades

The grooves in the lower sheave (mounted to the engine crankshaft) had excessive wear with sharp edges. The wear in the grooves of the upper sheave (which drives the rotor system) was unremarkable although it did sustain impact damage. All four V-belts were out of their grooves and laying across the upper sheave. Each belt had a raised crease down the center of the backing indicating the belts were riding much deeper in the grooves of the lower sheave due to the worn grooves. The friction surface of the belts appeared normal. Two of the belts sustained impact damage to their backing.

The aft face of the upper sheave had a scuff mark adjacent to the clutch centering strut. The strut had no marks on it but the frame tube that the strut was attached to was deformed. The frame tube adjacent to the forward face of the upper sheave was dented with no score marks and no scoring on the sheave face. The aft grooves of the upper sheave had imprint marks matching the size and shape of the starter ring gear teeth and the forward grooves had a large dent matching the size and shape of the top edge of the engine.

The upper sheave (which contains overriding or "Sprague" clutch) rotated smoothly on the shaft when rotated by hand in a clockwise direction (looking forward) and locked on the shaft when rotated in a counterclockwise direction.

The lower and upper support bearings for the belt tension actuator rotated smoothly by hand. The upper bearing attachment was fractured from the actuator housing and the motor was fractured from the gear drive. The surfaces of both fractures were rough and matte gray in color. The belt tension actuator extension distance was 1.5" measured between the scissor mounts.

The forward flex coupling was bent, and one arm of the main rotor gearbox input yoke was fractured and remained attached to the flex plate. The other ear of the flex plate was fractured from the input yoke. The surface of the fractures were angular and jagged.

The main rotor gearbox remained attached to the airframe. No oil was visible in the sight gauge as the gearbox was laying horizontally. The main rotor drive shaft was rotated by hand more than 360° with no anomalies, confirming continuity back through the input yoke. The driveshaft and mast tube were straight.

Both of the elastomeric teeter stops were dented across their centers. The droop stop tusk for main rotor blade serial number 10110 was fractured from the spindle. The surface of the fracture was angular and jagged. The droop stop tusk for main rotor blade serial number 10122 was bent. Both droop stop blocks remained in place.

The main rotor hub surfaces adjacent to the blade spindle boots had very light contact marks from the boots.

Main rotor blade serial number 10110 remained attached to the hub and the inboard six feet of afterbody (skin and honeycomb) remained attached to the spar. The remaining afterbody was separated from the spar, portions through tearing of the skin, portions through the joints. The surface of the separated joints of skin and spar had layers of adhesive that remained adhered, the surface of the tearing was angular and jagged. The spar was bent upward about 80°, four feet outboard of the hub, and a slight bow upward at mid-span. The outboard three feet of blade was completely separated and recovered 273 ft from the main wreckage. The surface of the fracture at the spar was angular and jagged. One foot of the afterbody outboard of the fracture was crushed from the trailing edge up to the spar with brown transfer marks consistent with tree residue on the upper surface. This section was bowed back (opposite the direction of rotation) slightly. All of blade 10110 was accounted for except for about 3 inches of spar, from an area about 3 ft inboard of the tip.

The inboard four feet of main rotor blade serial number 10122 remained attached to the hub. The outboard section was fractured in several places. The surface of the fractures in the spar and skin sections were angular and jagged. The surface of the fractures of the skin to spar joints had layers of adhesive that remained adhered. About 2 ft of blade length from an area inboard of the tip, and the outer most 6 inches of the tip, were not recovered.

Some blade remnants were found with wood debris in the leading edge and/or brown chordwise streaks consistent with tree material.

The intermediate flex coupling was bent slightly, and one arm of the tail rotor forward yoke was fractured and remained attached to the flex plate. The other ear of the flex plate was fractured from the forward yoke. The surface of both fractures were angular and jagged. The frame tube adjacent to the intermediate flex coupling had score marks running in the direction of rotation of the coupling.

The tail rotor driveshaft was separated from the tailcone leaving the damper bearing housing and hanger inside the tailcone. The hanger was separated from the support bracket and the friction arm was bent. The tail rotor driveshaft was bent slightly in several places. There were scuff marks and scratches along the length of the shaft running mostly lengthwise.

The aft flex coupling was bent, and the flex plate was fracture separated from the tail rotor gearbox input yoke. The surface of the fracture was angular and jagged.

The tail rotor gearbox remained attached to the separated aft section of tailcone. Oil, blue in color, was visible in the sight gauge. The output shaft was straight. The output shaft was rotated by hand more than 360° with no anomalies confirming continuity back through the input yoke.

Both tail rotor blades remained attached to the hub/gearbox and were dented on both their leading and trailing edges.



Figure 28 - V-Belts on Upper Sheave



Figure 29 - Lower Sheave



Figure 30 - Upper Sheave



Figure 31 - Forward Flex Coupling



Figure 32 - Main Rotor Gearbox



Figure 33 - Inboard Section of Main Rotor Blade S/N 10110



Figure 34 - Main Rotor Blade S/N 10110



Figure 35 - Mid-Section Afterbody of Main Rotor Blade S/N 10110



Figure 36 - Outboard Section of Main Rotor Blade S/N 10110



Figure 37 - Outboard Section of Main Rotor Blade S/N 10100 - Brown Residue on Upper Surface



Figure 38 - Inboard Section of Main Rotor Blade S/N 10122



Figure 39 - Mid-Section of Main Rotor Blade S/N 10122

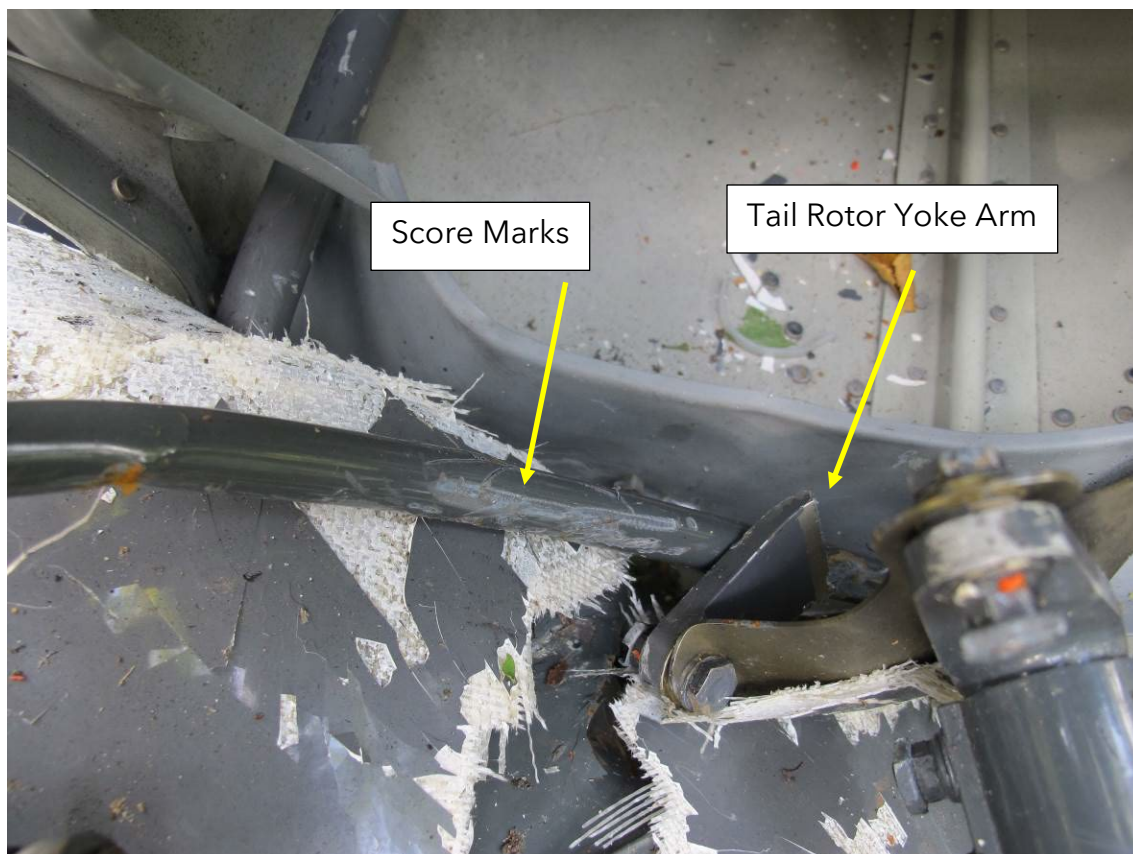


Figure 40 - Score Marks on Frame Tube Adjacent to the Intermediate Flex Coupling and Fractured Arm of Forward Tail Rotor Yoke



Figure 41 - Tail Rotor Drive Shaft



Figure 42 - Tail Rotor Gearbox and Blades

7.0 Engine Examination

The helicopter was equipped with a Lycoming model IO-540-AE1A5, serial number L-32231-48E, 6-cylinder fuel injected 260 HP engine.



Figure 43 Engine Data Plate

The engine came to rest upright with the engine mounts fractured. It remained partially attached to the fuselage through cables, wiring and hoses.



Figure 44 - Engine as Found



Figure 45 - Engine - View of Top

All cylinder induction and exhaust tubes were damaged, some were crushed, fractured or separated from the engine.



Figure 46 - Engine - View of Left Side (Note: The engine Faces Rearward in in the Helicopter)

The oil sump was damaged and partially separated from the crankcase.

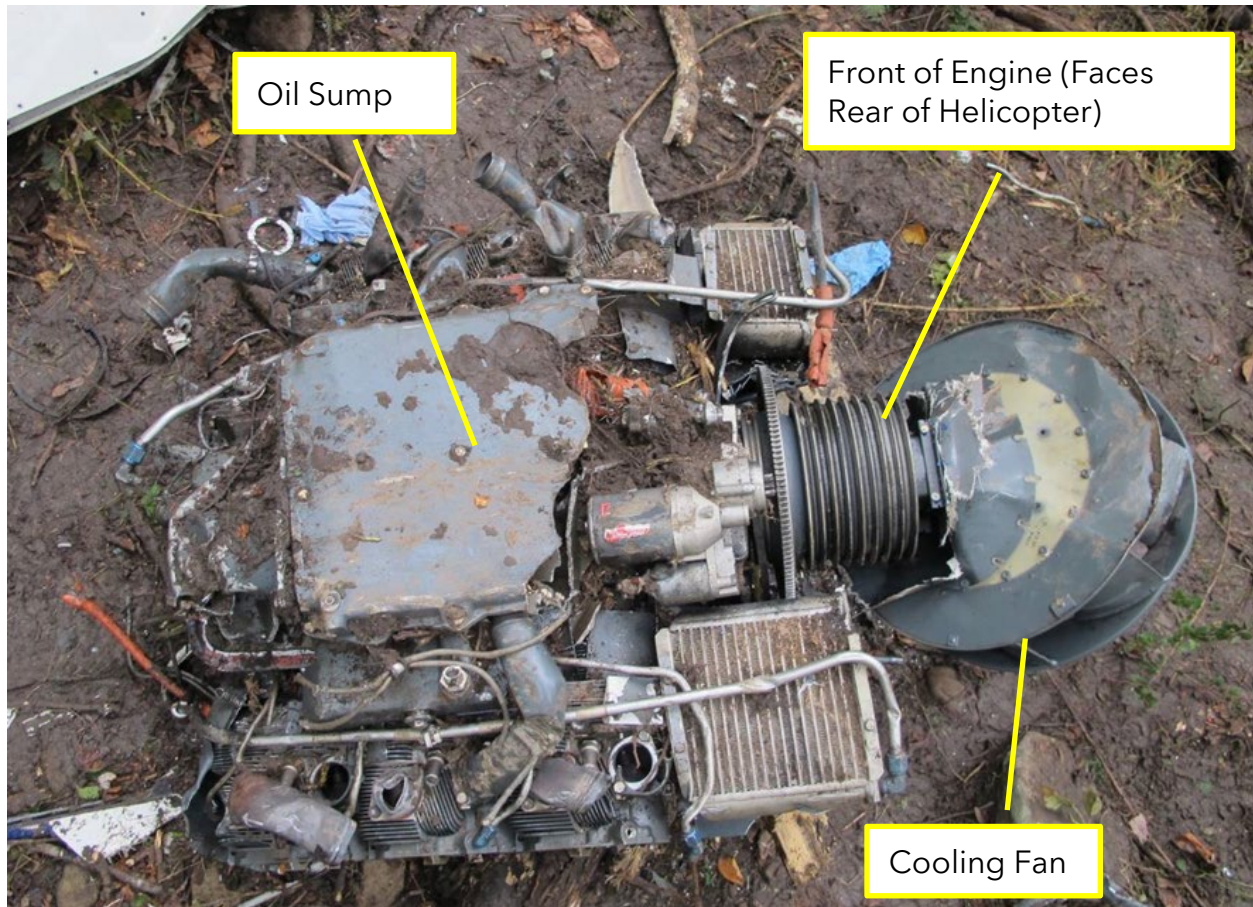


Figure 47 - Engine - View of Bottom

The accessory case at the rear of the engine was impact damaged and most of the cover was separated and fragmented.

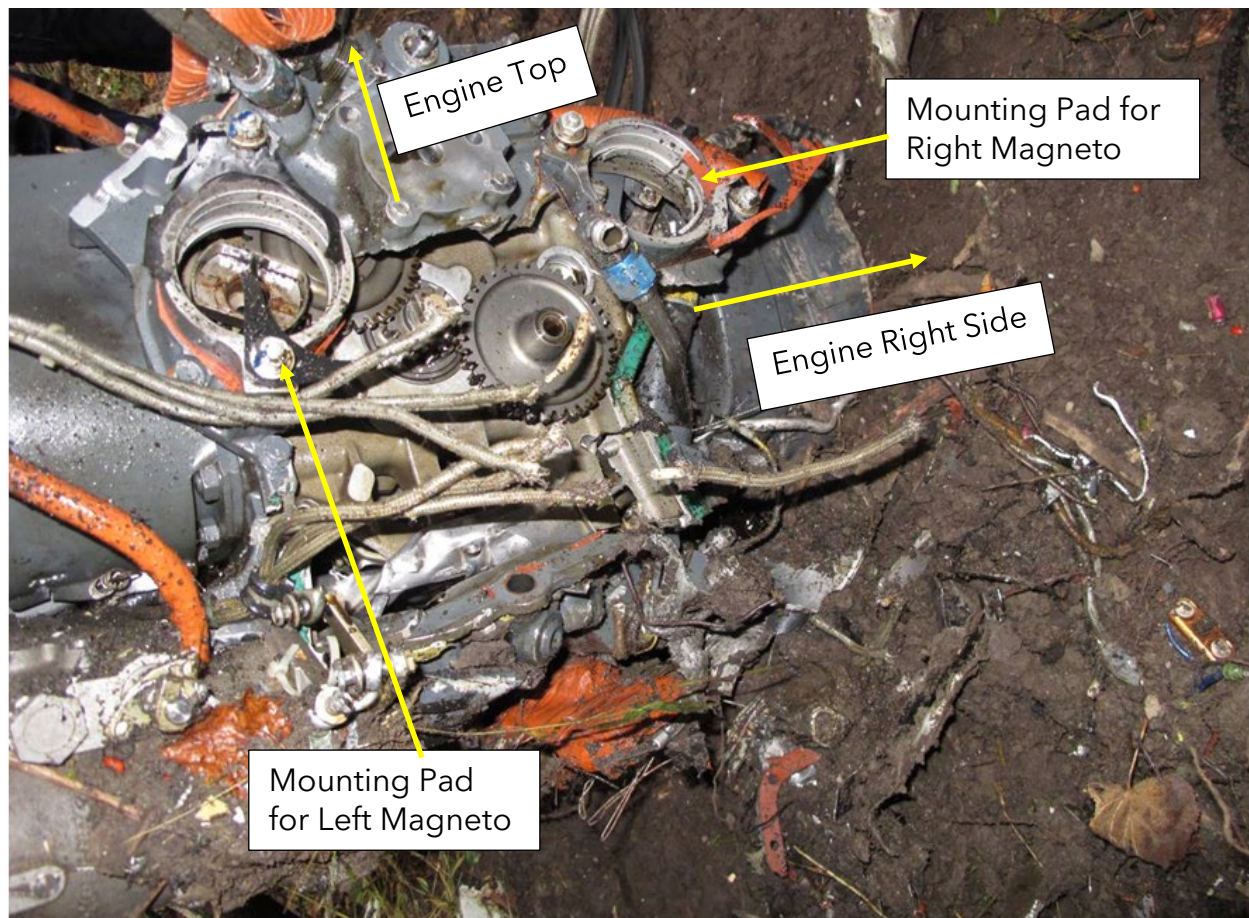


Figure 48 - Engine - View of Rear (Accessory Section)

The engine's spin-on oil filter and its adapter were separated from the engine. The filter housing was impact damaged, the top was torn open, and the filter element was partially dislodged with portions covered in dirt. The dirt was the same color and consistency of the soil at the accident site. The damage and subsequent exposure of the filter element (primarily to soil) precluded a definitive examination of the element for pre-impact debris. No metallic material was found in the element. The engine's internal oil sump screen contained a trace amount of debris but was unobstructed.



Figure 49 - Engine Spin-On Oil Filter (top) and Internal Oil Sump Screen (bottom)

The air filter was separated from the engine, crushed, and the filter element was partially dislodged. No debris was found in the filter element.



Figure 50 - Engine Air Filter

The fiberglass scroll that surrounds the cooling fan as severely impact damaged. No scoring marks were found on the inside of the scroll on the outer edges of the cooling fan. A 3 inch score mark was found on the inside of the metal fan lip, which lines the inside of the hole at the rear of the scroll.

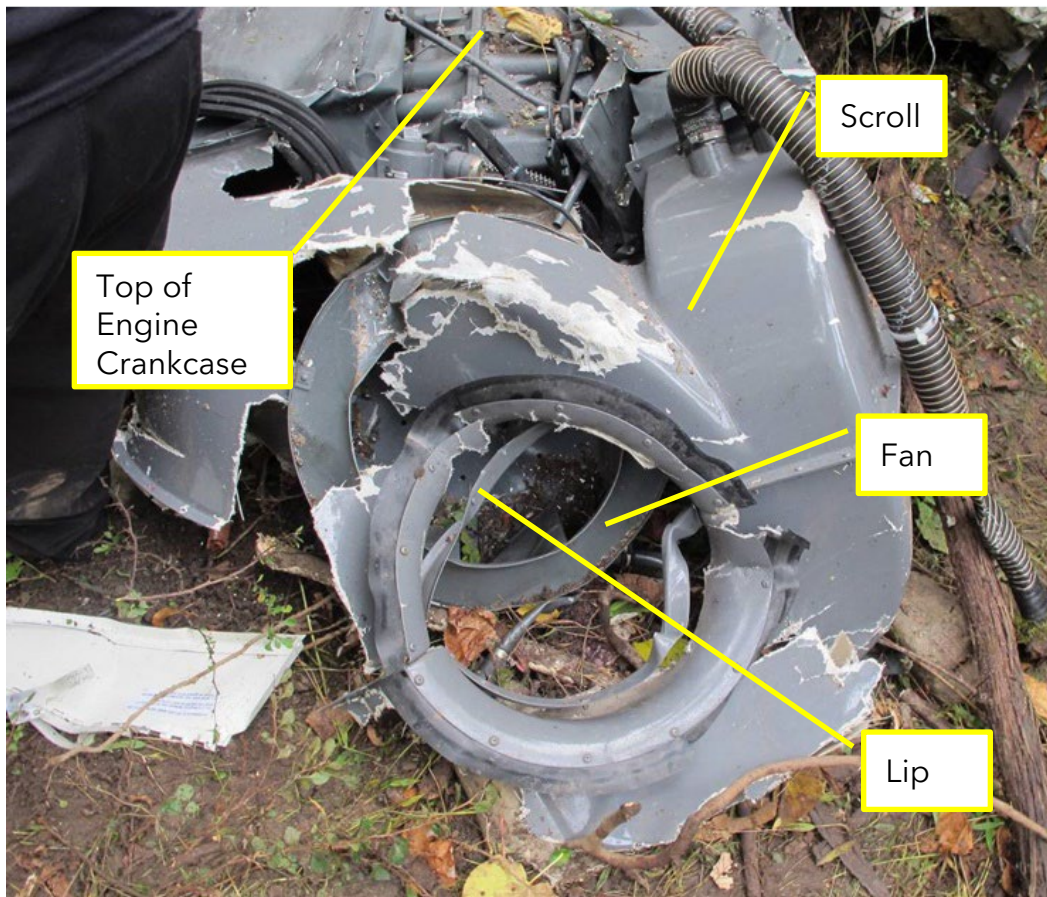


Figure 51 - Cooling Fan and Scroll



Figure 52 Fan Lip

The cooling fan was partially separated from the fan hub and bent aft at the 6 o'clock position. The outboard surface of the fan blade at the 12 o'clock position was dented on its trailing edge, just aft of center, in line with the location of the tail rotor intermediate coupling. The next blade in the clockwise direction also had a dent on its trailing edge, in line with the tail rotor control tube attachment hardware, located on the inboard arm of the bell crank.

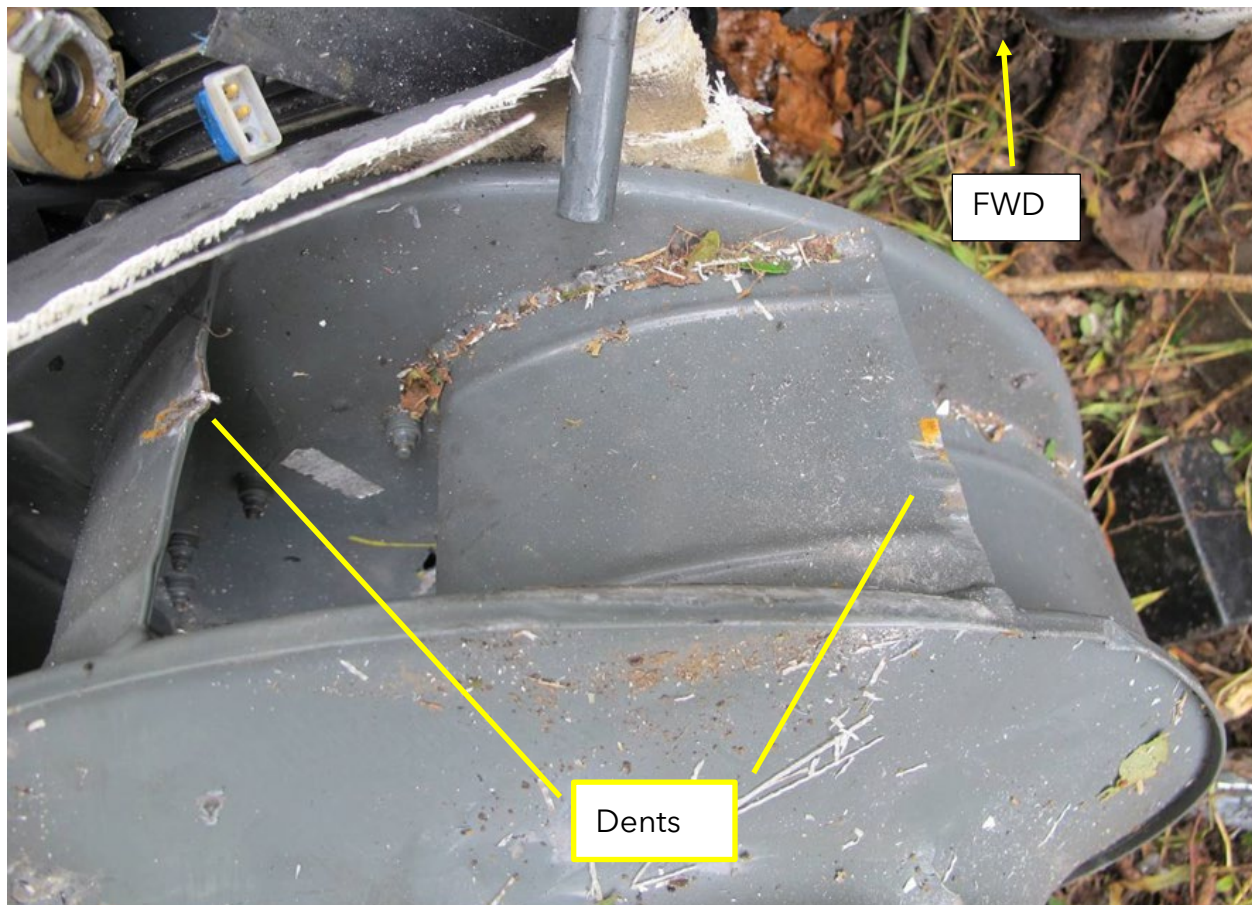


Figure 53 - Cooling Fan Blade Damage

Both magnetos were separated from the engine, and damaged. All of the ignition leads were broken in multiple locations. Remnants of each of the lead ends remained in the magneto harness assemblies. The right magneto case and its capacitor were impact damaged. It could not be rotated by hand as found. A portion of the case was dented inward and impinged on the distributor gear. After prying the case pieces away from the gear, the magneto rotated freely. However, when rotated with an electric drill, it did not produce spark at any of the ignition leads.

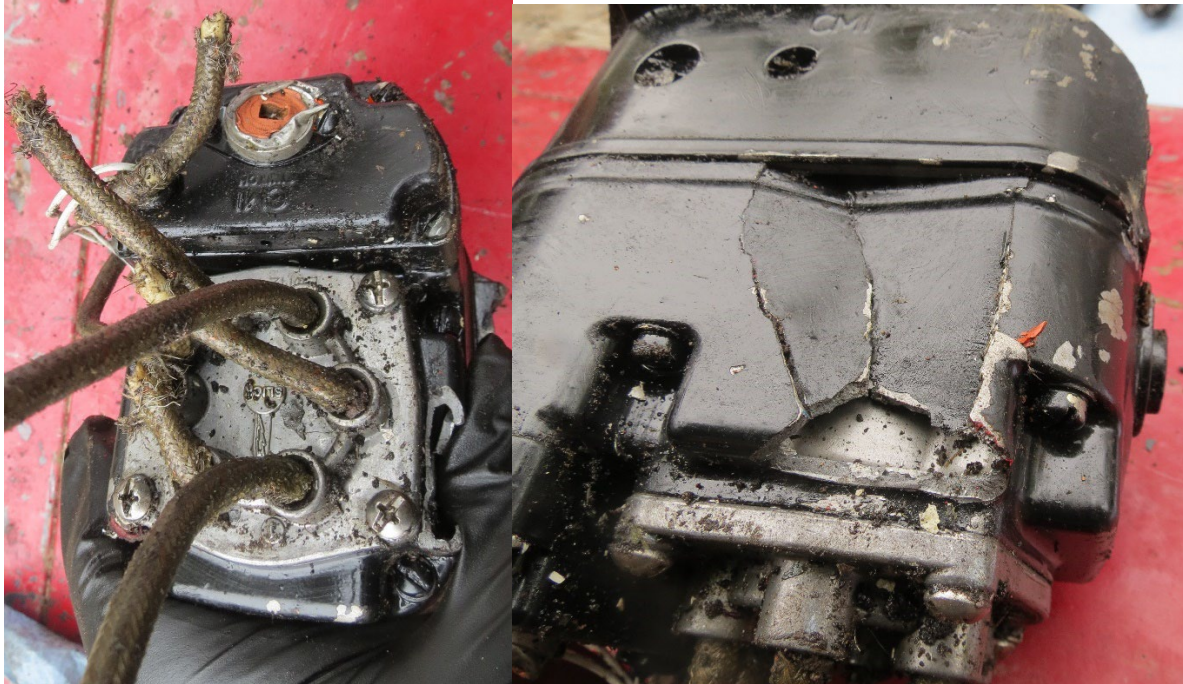


Figure 54 - Right Magneto

The left magneto was fractured and separated into two pieces and could not be field tested.

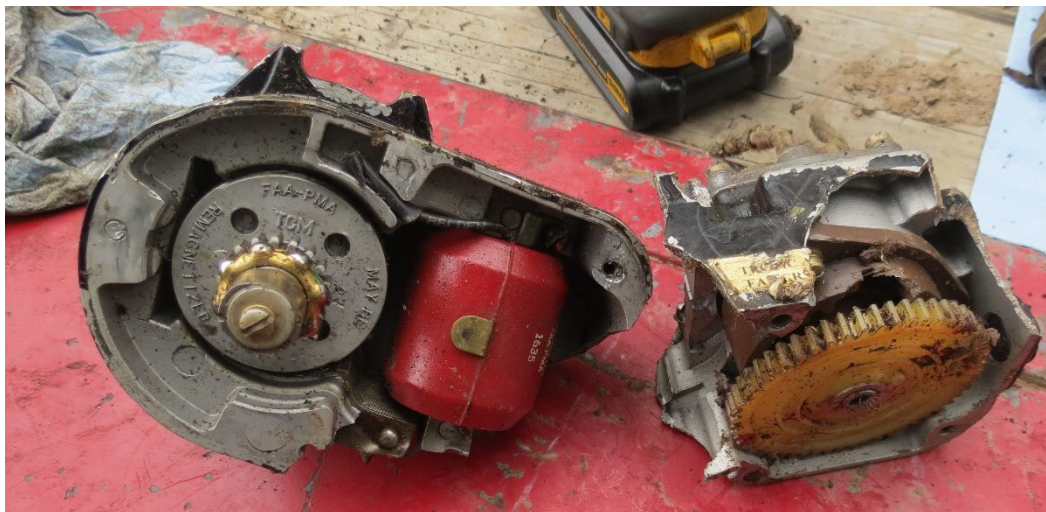


Figure 55 - Left Magneto

Both magnetos were sent to the manufacturer for further examination under the oversight of an NTSB investigator. The right magneto was installed in its as received condition on a test bench. It did not produce spark. The damaged capacitor was replaced, and the magneto was retested on the test bench. It operated normally.

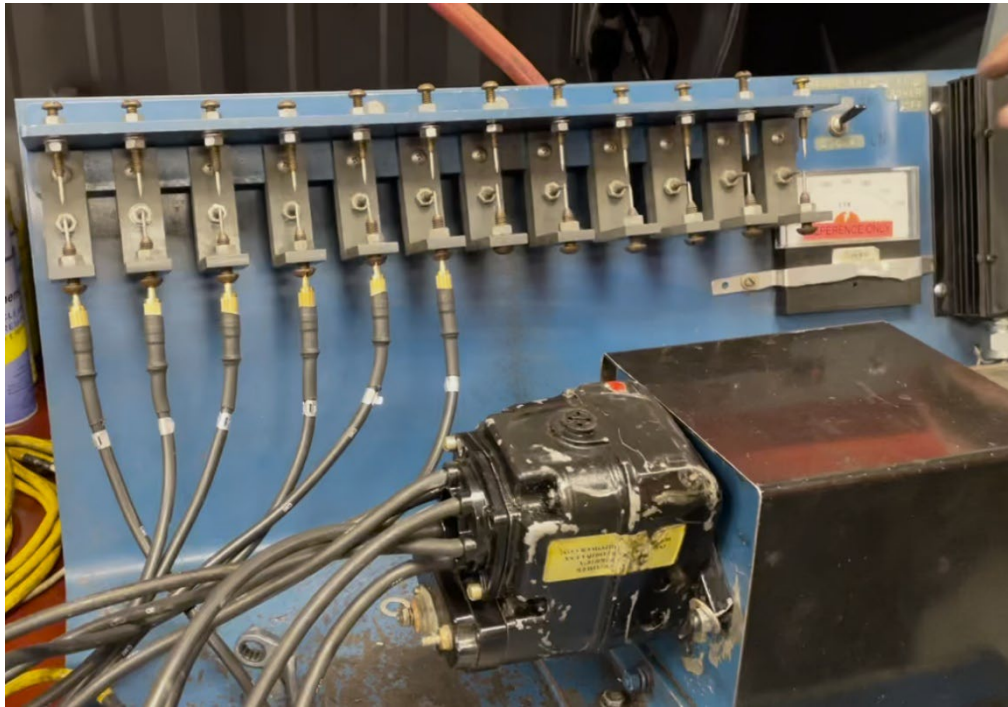


Figure 56 - Right Magneto on Test Bench

The left magneto's magnet had magnetism, its distributor gear and electrode were intact. The coil wire was separated. The half of the case containing the ignition points was not recovered. The magneto could not be tested on the bench.

The electrodes of all 12 spark plugs were undamaged and "worn normal" when compared to the Champion Check-A-Plug chart. The No. 1 bottom spark plug was oil soaked. All other spark plug electrodes were light brown in color, consistent with normal combustion. The Nos. 2, 4 and 6 spark plugs could not be removed from the engine, their condition and color were observed via borescope.



Figure 57 - Spark Plugs

The fuel injector servo was impact separated from the engine and partially fragmented. The throttle control rod end was fractured. A portion of the rod end remained attached to the servo throttle control arm. The mixture control cable wire was not attached to the servo mixture control arm. The bolt and attachment hardware which is to secure the cable wire to the servo mixture control arm was not present. The control wire sheath remained attached to its mounting bracket, the bracket was bent outward from the servo body. Lengths of the sheathing were stretched in several locations. The mixture arm was bent inward toward the servo housing and was positioned at the full lean (idle cutoff) position. The servo fuel inlet screen was removed and was absent of debris. Liquid with color and odor consistent with 100LL aviation gasoline drained from the servo when the screen was removed. The servo regulator section was partially disassembled and no damage to the internal rubber diaphragms or other components noted. The regulator cover brass plug was secure.



Figure 58 - Fuel Servo as Found



Figure 59 - Mixture Control Wire Sheathing Stretched Areas

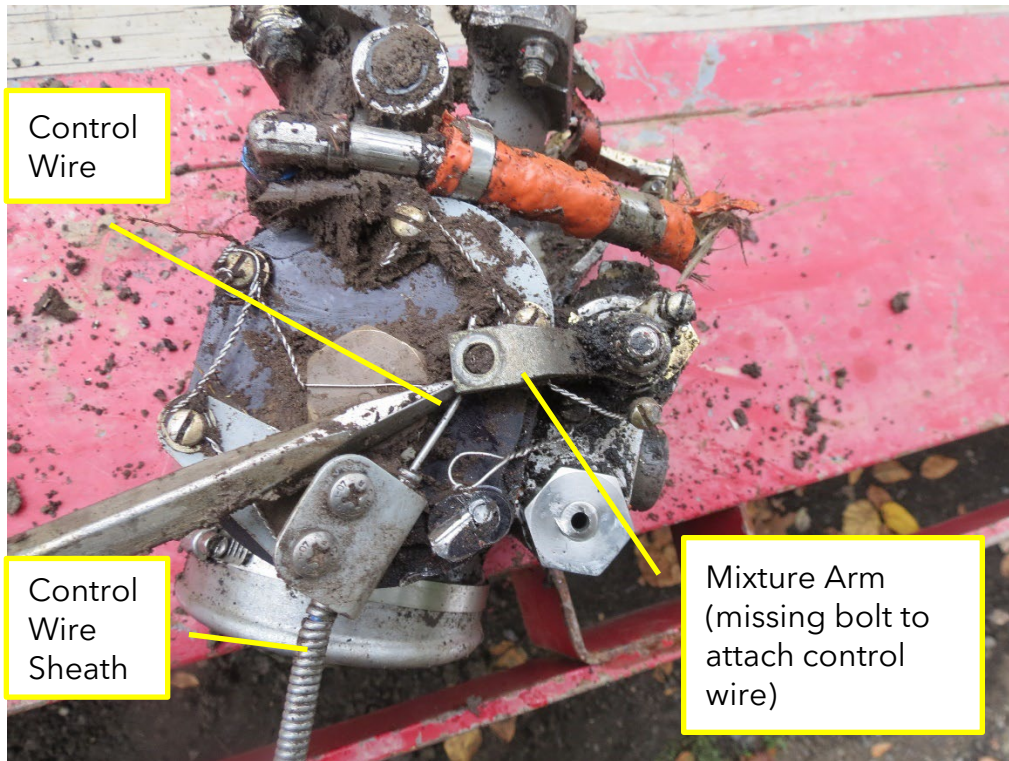


Figure 60 - Fuel Servo Mixture Arm



Figure 61 - Fuel Servo Diaphragms (left) and Inlet Screen (right)

The flow divider remained attached to the engine and no damage was noted. The injector lines were secure. The flow divider was partially disassembled and no debris or damage to the rubber diaphragm observed. The injector nozzles were unobstructed. No fuel was present in the flow divider or the injector lines.

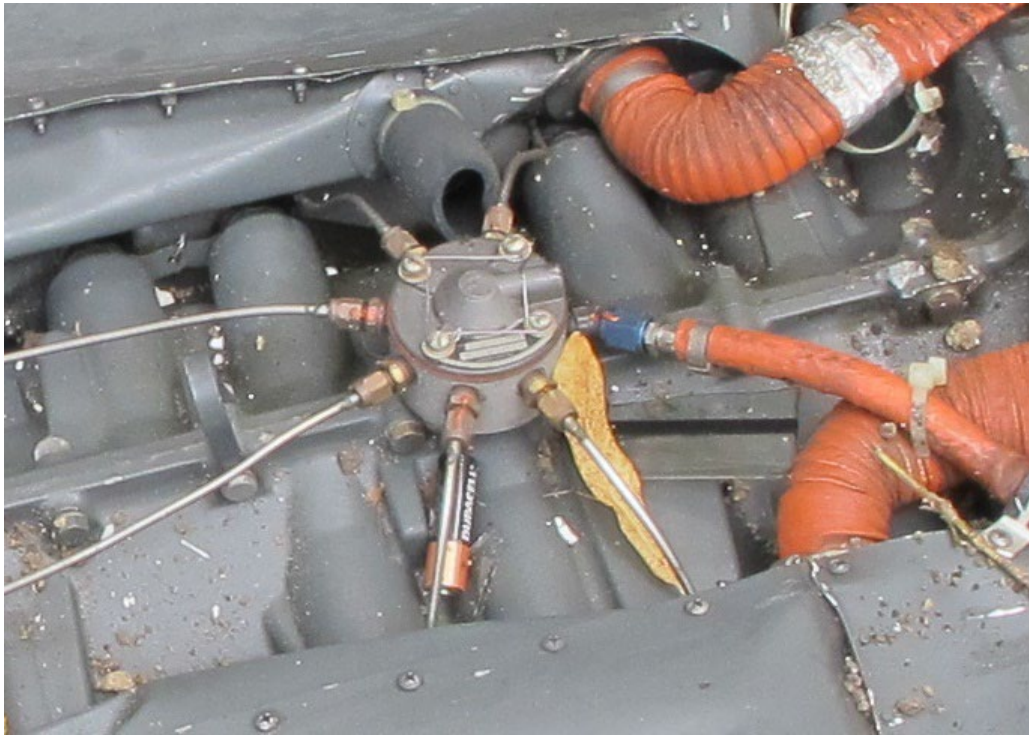


Figure 62 - Flow Divider as Found



Figure 63 - Flow Divider - Partially Disassembled



Figure 64 - Fuel Injector Nozzles

The engine driven fuel pump was fractured, and the pumping section separated from the mounting plate. The rubber diaphragms were impact damaged.

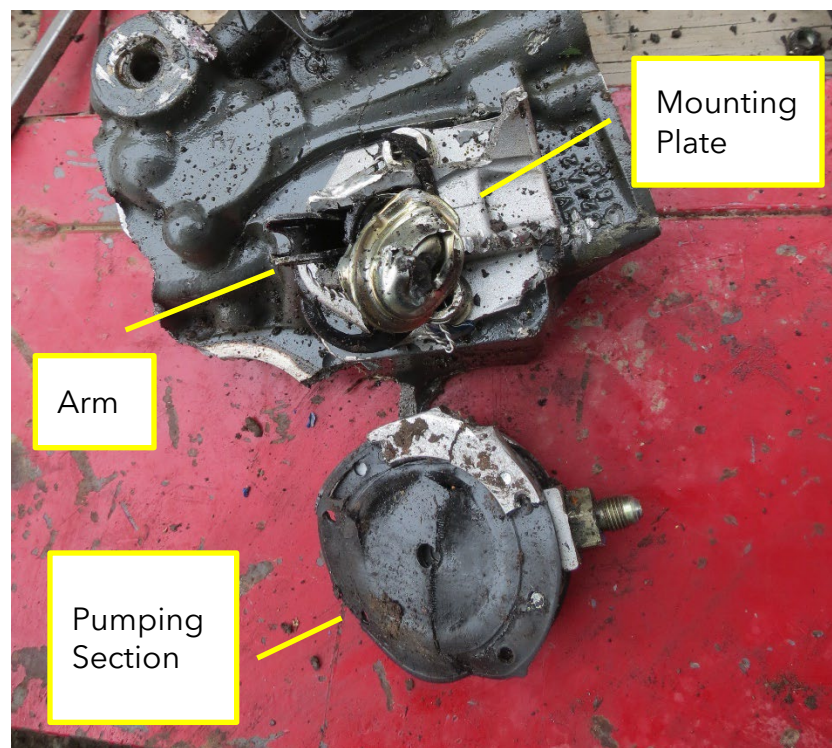


Figure 65 - Engine Driven Fuel Pump

Oil drained from the engine as it was moved to facilitate examination. The crankshaft was rotated by turning the cooling fan by hand. Thumb compression and suction was observed at the spark plug holes on all six cylinders. Crankshaft continuity was confirmed by observing the rotation of the accessory gears at the rear of the engine in concert with the rotating cooling fan at the front of the engine. Valvetrain continuity was confirmed as the crankshaft was rotated. All valve push rods and rocker arms were undamaged and operated as expected. The interior of each cylinder was observed using a lighted borescope with no anomalies noted.

Submitted by:

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