



Rolls-Royce

Engine Investigation Report

**Rolls-Royce Corporation
Model 250-C20B**



Model 250-C20B/J

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Air Safety Investigations**

**Pauley's Helicopter Services, Inc.
Jordan Valley, Oregon**

**Accident date: 26 May 2017
Investigation date: 29 June 2017
Engine exam date: 4 October 2017
Report date: 16 February 2018**

Background

On 26 May 2017, a Bell 206B3, registration number N24FS, was substantially damaged following a forced landing near Rockville, Idaho. The pilot, who was the sole occupant of the helicopter, was seriously injured. Daytime visual meteorological conditions prevailed and no flight plan was filed for the local flight, which originated from a private staging area about 5 minutes prior to the accident. The helicopter was engaged in Part 137 aerial spraying applications during the accident flight.



On 29 June 2017, representatives from the National Transportation Safety Board, the Federal Aviation Administration, Rolls-Royce, and Bell Helicopter examined the wreckage at SP Aircraft at the Boise, Idaho airport.

This report presents the observations made during the investigation.

Aircraft Information

Model	Bell 206B3
Serial Number	2040
Registration Number	N24FS
Airframe Total Time	15,461.2 Hours
Hobbs	1518.4
Last Inspection	33.8 Hours

Engine Information

Engine Model	Rolls-Royce 250-C20B
Rating:	420 HP
Serial Number	CAE-831608
Engine Total Hours/Cycles	11,244.6 Hours / UNK Cycles
Last Inspection (100 Hr)	33.8 Hours

Accident Flight

NOTE: The author of this report did not attend the accident site examination but was provided photographic documentation by the NTSB - IIC.

The aircraft was engaged in spot spraying of white top weed vegetation. The pilot reported that he had 25 gallons of fuel on board and that after the helicopter was reloaded with 80 gallons of chemical, he proceeded to a nearby field to begin an aerial application. The pilot said that he performed two application passes each being approximately 1000 feet in length.

After executing a 180-degree turn at an altitude of about 40 to 50 feet above ground level (agl), he heard a grinding noise immediately followed by a loud bang and subsequent loss of power. The pilot stated that he immediately initiated an autorotation landing to a nearby field. However, he did not have enough forward airspeed and main rotor rpm to flare, which resulted in a hard landing.

A light swirling wind prevailed at the time of the accident with an outside air temperature of 55°F and cloudy skies.

Altitude: 4595ft

Datum: WGS-84

Azimuth/Bearing: 207° S27W 3680mils (Magnetic)

Elevation Grade: -001%

Horizon Grade: -001%

Zoom: 1X



Aircraft at Accident Site

Aircraft Examination

On 29 June 2017, the aircraft was presented for examination in the SP Aircraft hangar at the Boise, Idaho Airport. The examination was attended by Rolls-Royce, Bell Helicopter, and the NTSB.

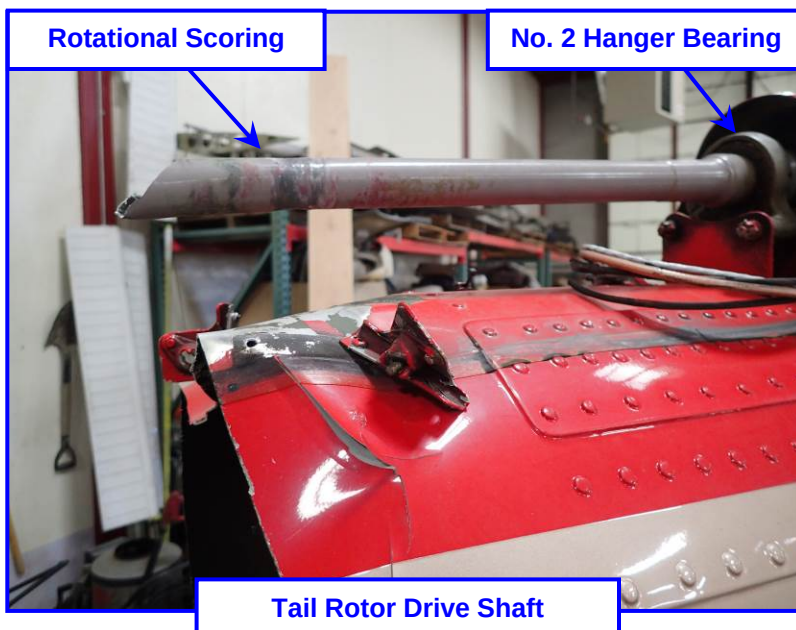


As-Recovered Condition of Helicopter¹

¹ To facilitate ease of recovery and ground transport the tail boom and components were mechanically removed/cut off. These actions did not compromise documentation of the aircraft for investigative purposes.

The aircraft exhibited damage consistent with impacting level terrain and nearly vertical forces. The right hand skid had fractured aft of the front cross-tube connection and completely separated from the aft cross-tube. The right front strut was splayed outward. The fuselage structure contained several locations of buckling damage, wrinkled skin, and broken Plexiglas. The belly-mounted chemical tank sustained vertical crush damage.

The main rotor mast was tilted forward from its original position and the forward end of the main rotor transmission had partially collapsed the forward cabin ceiling structure. The main rotor blades were still attached to the blade grips and appeared undamaged. The tail boom sustained buckling damage approximately 12-inches aft of the fuselage attachment point and 10-inches forward of the tail rotor output drive shaft.



Rotational Scoring

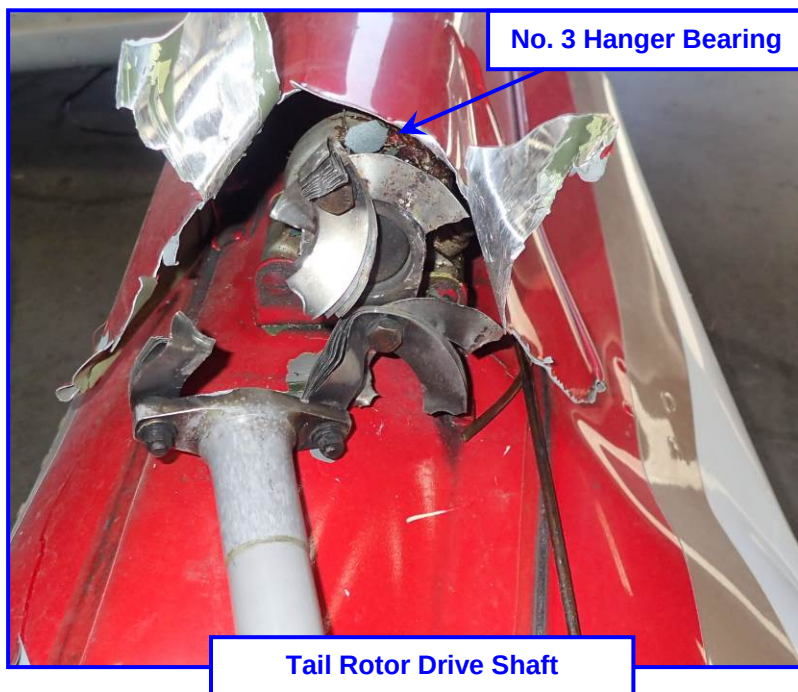
No. 2 Hanger Bearing

Tail Rotor Drive Shaft

The tail rotor drive shaft sustained a total of 3 fractures along its length with evidence of torsional breakage and rotational scoring.

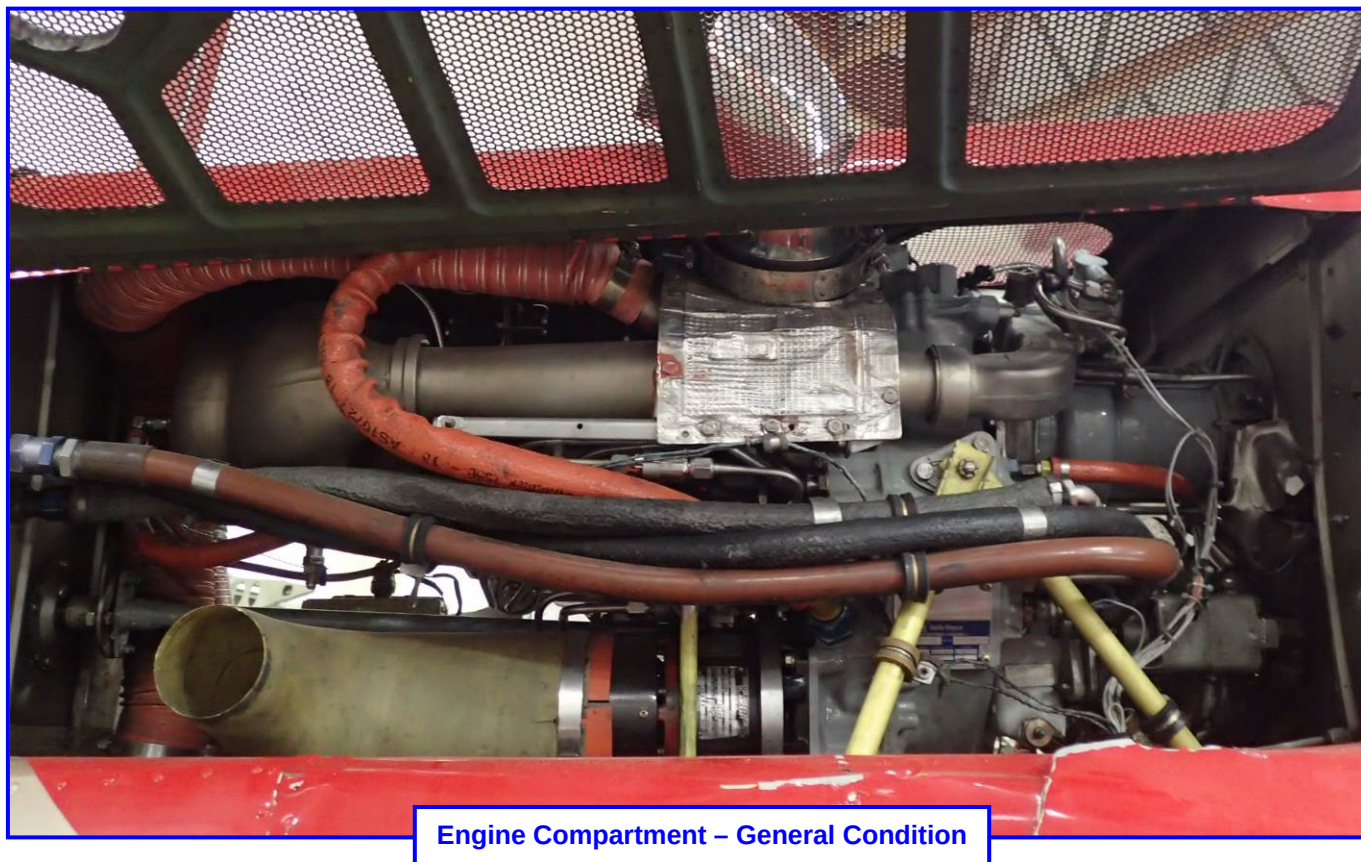
A mid-span section of drive shaft had liberated from its hanger bearing allowing leading to significant rotational whipping damage to the tail boom and drive shaft sheet metal cover adjacent to the horizontal stabilizer.

The KAflex® coupling frame forward of the 3rd hanger bearing contained numerous fractures within its disc stack. The surrounding sheet metal structure was also heavily damaged drive shaft whipping.



The engine remained within the engine compartment and the engine mounts showed no immediate signs of damage. Initial inspection of the engine exterior did not reveal any obvious signs of damage from impact forces, internal engine failure, or evidence of fire.

All engine B-nuts and fittings were checked by hand for proper torque. All were found to be at least hand tight and marked with orange torque paint.



The engine to transmission drive shaft (short shaft) had separated by fracture at the KAflex® coupling frames forward of the freewheeling unit and at the main rotor transmission connection.

The NTSB-IIC directed the KAflex® coupling, drive shaft, isolation mount, and related components to the NTSB lab in Washington, D.C. for further analysis.



Short Shaft Disconnection



Short Shaft Disconnection



Engine to Transmission Drive Shaft (Short Shaft) Disconnection

Control continuity was established from the collective twist grip to the engine. Controls were cycled fully from stop to stop, with no unusual resistance or excessive travel noted during the control movements.

Both N1 and N2 rotors could be rotated by hand and were smooth and quiet. Continuity from the power turbine to the power output and tail rotor output shafts was established.

The compressor inlet was accessed exhibiting extensive evidence of damage to the inlet guide vanes and 1st stage blades. A borescope was used to examine further into the compressor rotor. Additional damage was noted to at least stage 3.

Continuity was confirmed throughout the N1 rotor system from the compressor rotor to the starter-generator cooling fan. The 4th-stage turbine blades appeared undamaged as did the surrounding turbine sections and exhaust plenum.

The bleed valve was operated by hand. The poppet valve smoothly travelled its full stroke and exhibited no radial play. A functional check of the bleed valve using shop air pressure was not performed.

The aircraft was equipped with an inlet barrier filter which was mildly dirty but not obstructed.

There was no evidence of fuel or oil leaks within the engine bay. The fuel supply line was removed from the fuel spray nozzle; about 1 teaspoon of clean, bright fuel drained from the line. There was no evidence of obstruction in the fuel spray nozzle inlet.

Inlet Guide Vane Damage



Compressor Inlet



4th-Stage Power Turbine Blades

The fuel cut-off valve was found in the closed position. The fuel cut-off control in the cockpit was found in the OFF position. The cut-off valve was cycled and functioned normally as did the airframe fuel pump. Cockpit fuel gauge indicated the total fuel load on board at the time of recovery was approximately 14 gallons.

The airframe fuel filter housing was full upon removal and the filter exposed. The filter visually inspected clean with no evidence of contamination. The fuel line from the filter to the inlet of the fuel pump was removed at the pump. Fuel was present at the pump inlet and collected in a small container. The fuel appeared clean and clear.



Fuel Spray Nozzle

The fuel spray nozzle was removed and examined. The spray face exhibited a heavy carbon and soot appearance. There did not appear to be any blockage within the air distribution holes. The nozzle was not disassembled further.

Both the upper and lower Magnetic Chip Detectors (MCDs) were removed and examined. No evidence of flakes or related metallic debris was noted on either MCD. The lower magnetic chip detector plug was removed to facilitate oil drainage and an appropriate amount of oil (~1/2 liter) was drained from the gearbox.



Engine Pressure Oil Housing



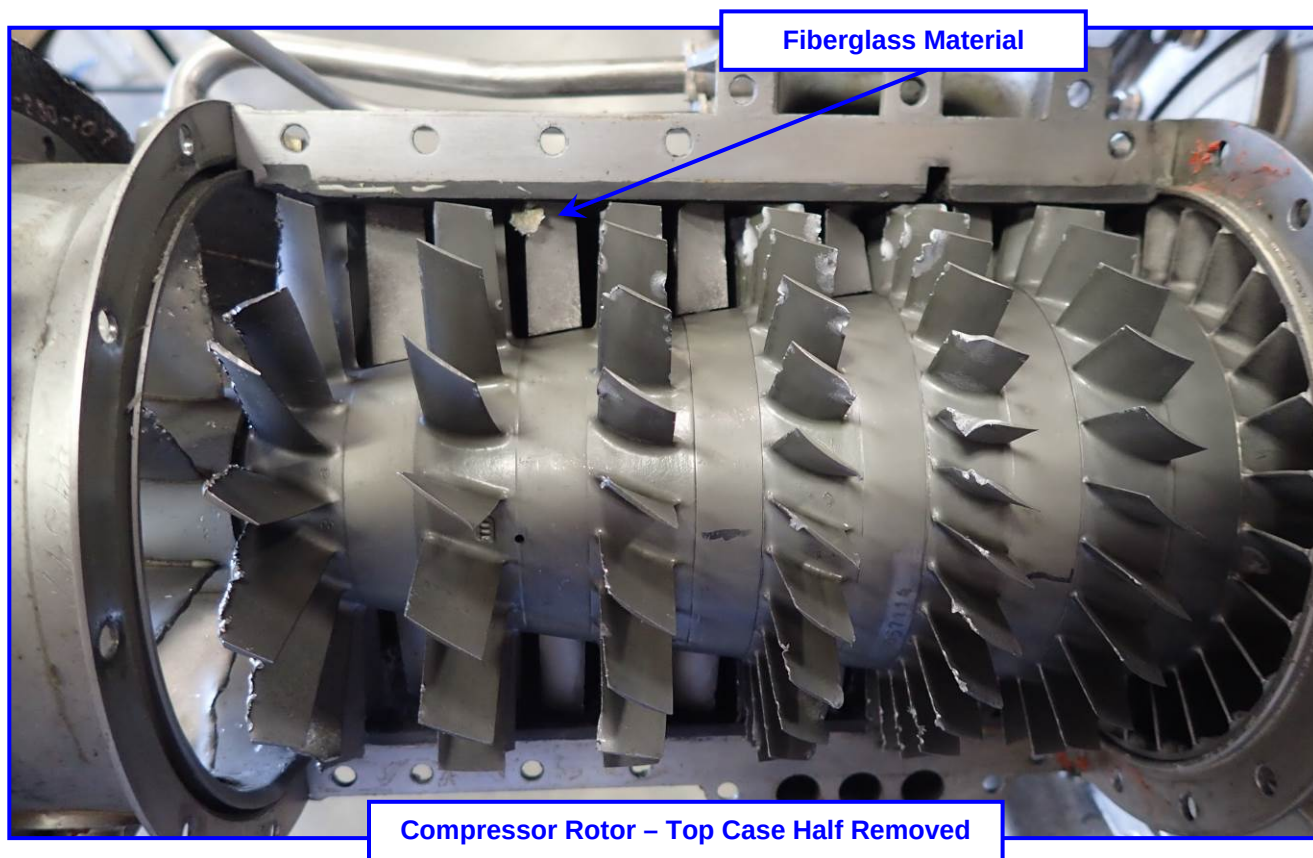
Engine Pressure Oil Filter

The aircraft was equipped with an airframe mounted external engine oil scavenge filter and was found to be free of contamination or ferrous metal. The engine pressure oil filter was removed and inspected clean of ferrous metal, foreign debris, or similar contamination. The oil reservoir registered full on the dipstick, and contained clean, bright oil with no suspended debris. Oil was present in the inlet and outlet lines to the engine accessory gearbox.

The 1st-stage gas generator turbine nozzle and 1st-stage turbine wheel were borescope inspected revealing no evidence of damage, thermal degradation, or abnormal combustion.

Per the request of the NTSB-IIC, the engine was removed for further on-site examination.

Inspection of the compressor inlet revealed clear signs of damage to the 1st-stage compressor blades. Borescope inspection revealed further damage to at least 3rd stage vanes (the limit of the borescope equipment). As a result of these findings the IIC requested removal of a compressor case half to assess the full extent of the damage.



Compressor blade damage was noted back thru stage 6. The majority of the damage appeared sharp and jagged with varying amounts of missing material and curl blade tips. Numerous areas of blade damage displayed material deformation in the direction opposite engine rotation. The 1st-stage blades were heavily damaged with nearly all blades exhibiting missing material presenting a tapered profile from the base to the tip of each blade. Several of the 1st-stage blades contained span-wise twisting and bending.

A few pieces of fiberglass material were detected between the 2nd-stage blades and vanes. These pieces appear to have come from the fiberglass inlet plenum structure.



Based on the initial findings, the NTSB-IIC recommended the engine be prepared for further examination at AeroMaritime in Mesa, AZ, which is a Rolls-Royce Authorized Maintenance Center (AMC). An engine shipping container was delivered to the SP Aircraft facility where it was installed in the container. The engine was ground transported to AeroMaritime for examination.

Engine Examination

On 4 October 2017, the subject engine was removed from the shipping container at AeroMaritime's Mesa, AZ facility with NTSB-IIC oversight.

The shipping container was opened and the engine appeared in the same general condition as when it was examined in Boise, ID. The compressor and exhaust collector ducts were covered clear plastic wrap.

No evidence of damage or abnormal conditions was noted during the uncrating process.

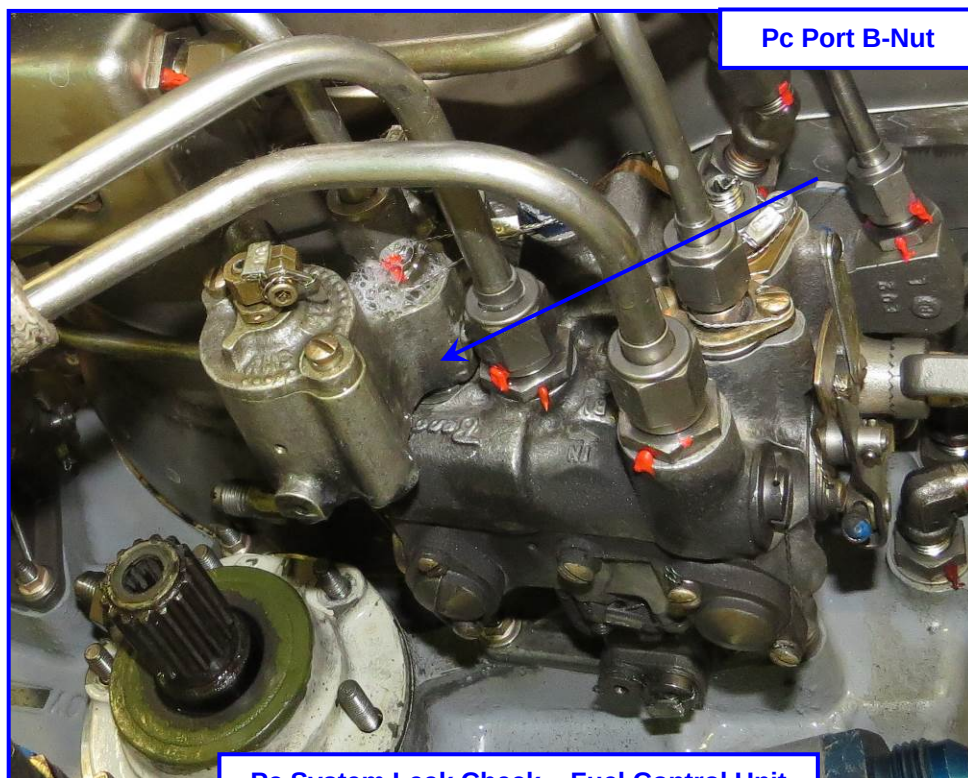
The engine was hoisted by overhead crane and placed into a turnover stand for further examination and preparation for compressor replacement.

Prior to disassembly for compressor swap, the Pc system was leak checked. Bubbling was detected at the B-nut connection with the Pc port on the fuel control unit.

All of the fuel control and power turbine governor b-nut connections were stripped with torque paint including the subject location. The Pc port B-nut at the FCU was at least wrench tight and could not be loosened with finger pressure.



Engine As-Received on Container Skid



Pc System Leak Check – Fuel Control Unit

The outer combustion case (OCC) was removed to visually assess the condition of the 1st-stage nozzle guide vane (NGV) and 1st-stage turbine wheel blades as well as the combustion liner.

Small amounts of metal debris flakes were noted in the cavity between the OD of the NGV and GG support at the 6:00 position. It was concluded that the most likely source of the debris was from the compressor rotor damage.

The associated combustion and turbine hardware exhibited no sign of abnormal burner profile, heat distress, or thermal deterioration.

To facilitate the compressor replacement the entire turbine module assembly was removed from the gearbox. Following removal additional bits of metal debris flakes were found in the exhaust collector support. Both N1 & N2 turbine rotors turned freely but a slight scraping sound was noted when turning the power turbine. A borescope was inserted into one of the thermocouple ports which showed further evidence of metal debris throughout the turbine.



Metal Debris in NGV to GG Support Cavity

Given the metal debris and N2 turbine rotor scraping sound a collective decision was made to discontinue further preparation for compressor swap and engine test. The NTSB-IIC issued the direction to remove the power turbine governor & fuel control unit for further testing at Honeywell in South Bend, IN.

An update from the NTSB-IIC on 26-Jan-2018 indicated that fatigue cracks had been found on the KAflex® coupling and that further analysis is ongoing. The direction was then given by the IIC to forego the controls testing at Honeywell suggesting that they were not contributory to the event. Both the power turbine governor & fuel control unit were shipped back to SP Aircraft at the request of the NTSB.



Controls Being Packaged at AeroMaritime



Controls Prior to Shipping at AeroMaritime

Engine Maintenance and Records

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE-831608	6887190	91.5	11244.7
Gearbox	CAG-33122	6894171	91.5	15410.3
Compressor	CAC-42383	6890550	91.5	3443.3
Turbine	CAT-33450	23038241	91.5	7376.7
Governor	BR41952	23065123	1688.4	UNK
Fuel Control	319344	23065104	1817.4	UNK
Bleed Valve	FF14637	23053176	91.5	UNK
Fuel Pump	T1083	6899253	3127.2	UNK
Fuel Nozzle	ISL05927	23077068	470.4	UNK

Summary of Findings

There was no evidence of pre-impact fire, damage or malfunction of the engine.

There was evidence of engine and drive train rotation at the time of impact.

The severity of the impact coupled with the extensive rotational witness marks on both the N1 and N2 rotor systems, suggests the engine was operating at or near normal operating speeds at the moment of impact.

Based on the metallurgical findings on the airframe drive shafting components at the NTSB, the focus of the investigation has shifted to that area. A lab summary of the results from the NTSB may be provided to Rolls-Royce at a later date.