



Rolls-Royce

Engine Investigation Report

**Rolls-Royce Corporation
Model M250-C20B
Engine CAE-830577**



Model 250-C20B/J

**Nick Shepler
Air Safety Investigations**

**Owner: TRE Aviation Corp.
Operator: Van Horn Aviation LLC
Location: Fort McDowell, AZ**

**Accident Date: 16 April 2019
Investigation Date: 17-18 April 2019
Report Date: 5 June 2019**

Background

On April 16, 2019, at 0706 Mountain Standard Time, a Bell 206B3 experimental helicopter, registration N61PH, impacted an alfalfa field approximately 1 mile south of Fort McDowell, Arizona. The commercial pilot and pilot-rated passenger were fatally injured. The helicopter was destroyed.

The helicopter was registered to TRE Aviation Corporation and operated by Van Horn Aviation, LLC for research and development flight testing under the provisions of Title 14 Code of Federal Regulations Part 91. Visual meteorological conditions prevailed and a flight plan was not filed.



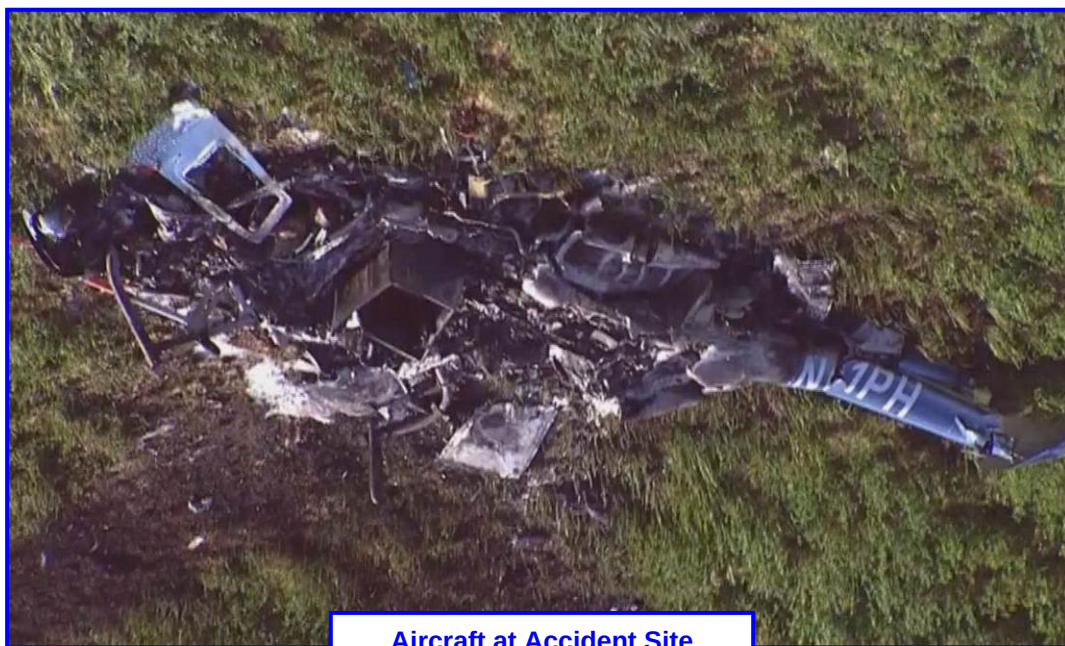
Aircraft File Photo

Recovery examination was carried out on 17-18 April 2019 at Air Transport in Phoenix, AZ. The examination was conducted under the auspices of the NTSB. Additional party members included the FAA, Rolls-Royce Air Safety, and Van Horn representatives. This report presents the observations made during the investigation. The NTSB Accident Number for this investigation is: WPR19FA109.

Accident Flight

The purpose of the flight was to evaluate developmental main rotor blades that had been installed on the helicopter. According to the operator, the helicopter was fueled for two test flight legs. The helicopter departed at 0545 for the first event and returned at about 0620, parked on the ramp with the engine at idle, and 100 lbs. of ballast was added to the helicopter.

Preliminary radar data showed that the helicopter departed at 0632 to continue the second leg of the test flight. The test flight legs consisted of multiple auto-rotations at maximum gross weight involving a simulated loss of engine power. The accident flight was the last test flight of the main rotor blades before the certification process.



Aircraft at Accident Site

A witness who was walking to a bus stop, about 1/3 mile northwest of the accident site heard a loud bang southeast of her position. She saw the helicopter falling from the sky and used her phone to video record the helicopter and several other objects descending to the ground before losing site of it behind trees along the road from which she was positioned.

Initial examination of the main wreckage revealed postcrash fire and impact damage consistent with a right side-down, nose-level attitude during ground impact. The main rotor hub assembly, vertical tail, tail rotor assembly, tail rotor driveshaft, and forward induction cowl fairing separated from the main wreckage and were found in the debris field. The debris field was about 1 mile long and 1,000 ft wide, covering an area of wooded desert terrain and flood irrigated alfalfa fields. The wreckage was recovered to a secure location for further examination.

Aircraft Information

Model	Bell 206B3
Serial Number	3282
Registration Number	N61PH
Airframe Total Time	7,114.8 Hours
Hobbs:	73.8 Hours
Last Inspection:	7.2 Hours

Engine Information

Engine Model	Rolls-Royce 250-C20B
Rating:	420 HP
Serial Number	CAE-830577
Engine Total Hours/Cycles	9,337.1 Hours / 4,063 Cycles
Last Inspection (150/300-Hr)	7.4 Hours

Wreckage and Impact Information

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

The aircraft exhibited damage consistent with impacting in nearly vertical forces on its right hand side. A significant portion of the cabin structure and passenger compartment was consumed from a post-crash fire. The main rotor mast was heavily instrumented and was fractured just below the connection to the main rotor head. The tail boom was fractured aft of the horizontal stabilizer. Evidence of a main rotor blade strike was noted on the underneath side of the left hand horizontal stabilizer. The main rotor blades exhibited various levels of damage and broom-strawing of the carbon fibre layers.

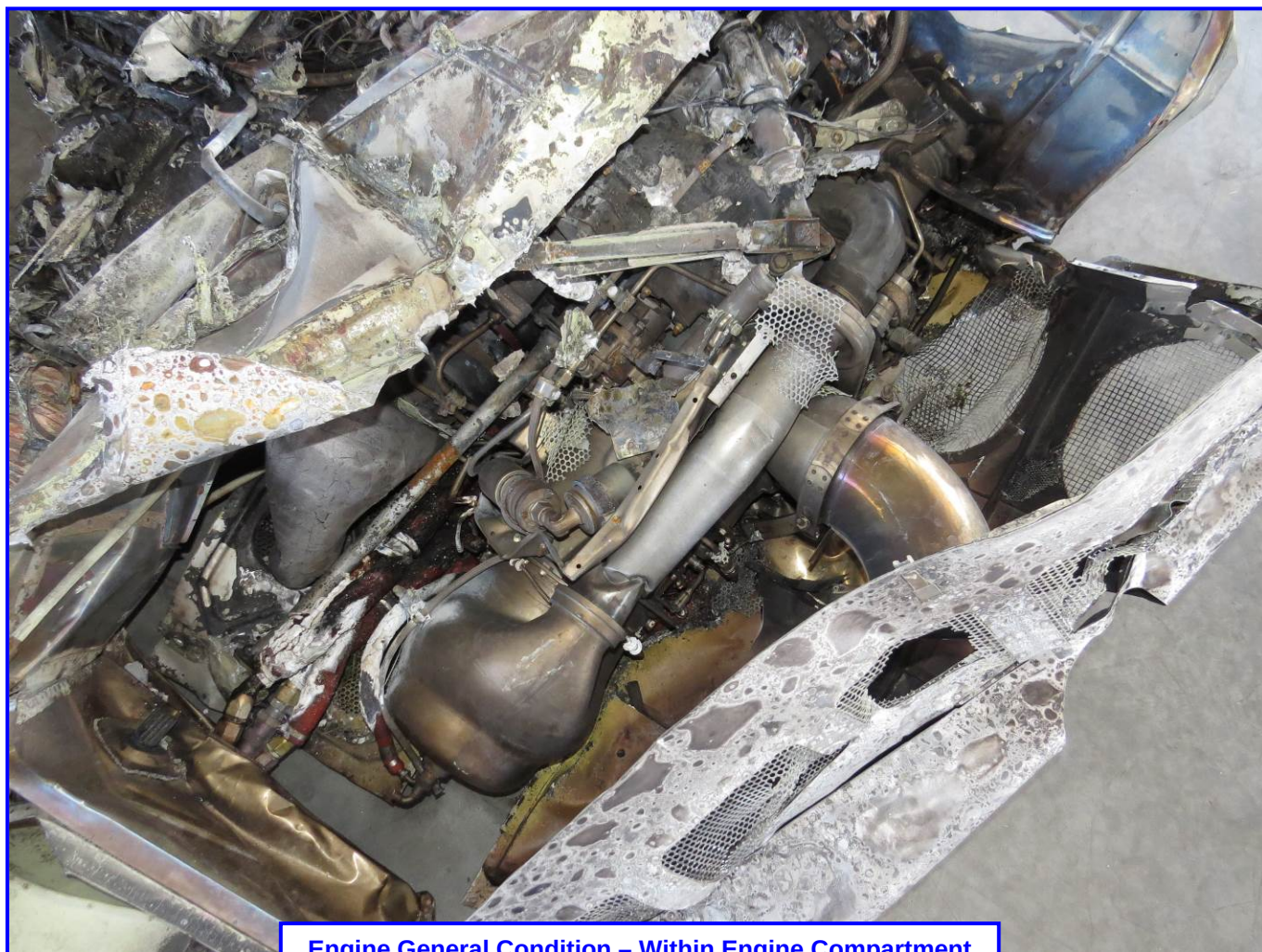
Dirt, vegetation, and various pieces of engine access panel material were found lodged inside the right hand diffuser scroll elbow and gearbox. Extensive impact damage was visible along the entire right hand side length of the engine from the diffuser scroll, exhaust collector & duct to the outer combustion case. Numerous ancillary rigid fuel, air, and oil tubes were severely bent, broken or crushed from impact forces. Damage to areas on the engine gearbox resulted in the fracturing of various rigid and flexible oil line connections.



Main Rotor Mast Instrumentation



Main Rotor Mast Fracture



Engine General Condition - Within Engine Compartment

The engine remained mostly intact within its mounts and the engine compartment with only the left hand side aft mount leg detached from the fuselage. The right hand exhaust duct was crushed over and nearly covering the outlet of the exhaust collector support. Both exhaust ducts were subsequently removed in order to extract the engine from the wreckage and to provide better visual access to the exhaust collector support and power turbine rotor. Visual and tactile inspection of the fuel, oil, and electrical connections that were not separated from their respective attachment points appeared secure including various B-nut connections when checked using hand pressure. The engine displayed no visible sign of pre-impact damage, fire, or mechanical malfunction.



Engine General Condition – Removed from Wreckage

The engine to transmission drive shafting was fractured at the KAflex® coupling fingers forward of the freewheeling unit and rotor brake assembly as well as at the input connection to the main rotor transmission.

Heavy rotational scoring was noted on the top surface of the isolation mount and at the input shaft to the main rotor transmission.

The tail rotor drive shaft section between the engine and aft firewall was disconnected at the oil cooler blower input spline. The shaft remained connected to the back of the engine gearbox. The shaft was able to rotate by hand in the direction corresponding to the functionality of the freewheeling unit.



Rotational Scoring on Isolation Mount



Engine to Main Rotor Transmission Connection

Three of the compressor inlet struts were either heavily dented or buckled from impact forces. A portion of the compressor inlet contained dirt and vegetation back to the 1st-stage vane row.

Several of the 1st-stage blades exhibited dents, abrasion, and curling at the leading edge tips. Heavy blade bending opposite rotor rotation was observed beyond the 1st-stage.

The lower compressor case half was crushed radially inward over the length of the rotor. A large circumferential tear approximately 4" in length was visible on the lower case half.

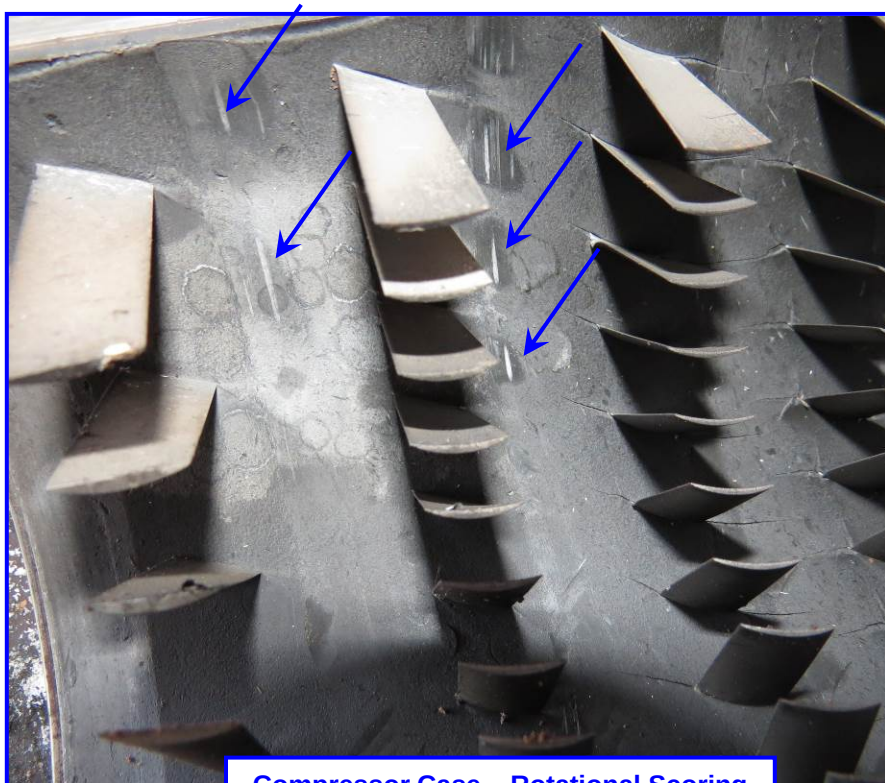


Compressor Inlet

The compressor case halves were later removed to assess the full extent of damage and to attempt rotational continuity of the N1 rotor system. Rotational scoring was noted on a portion of the upper case half in line with stages 2 & 3.

The lower case half showed extensive bending damage to the vanes in stages 1 thru 4. The black plastic inner case coating was also severely damaged and delaminated in large sections.

The compressor rotor blades in the area of inward crush damage on the lower case half were heavily rolled over and bent opposite the direction of rotation.

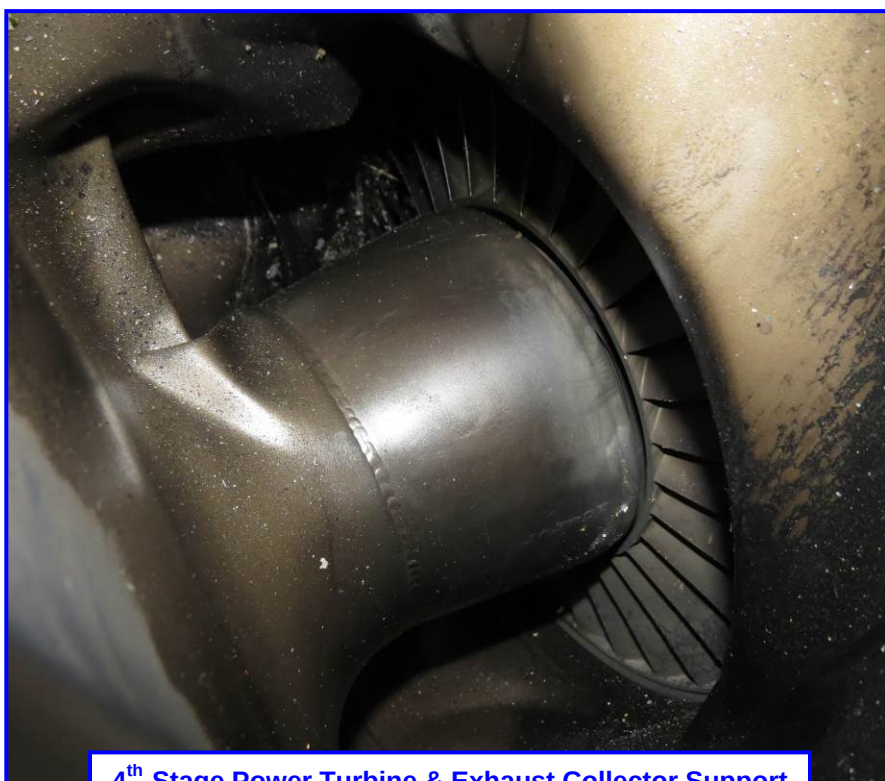


Compressor Case – Rotational Scoring

The 4th-stage power turbine blades did not display signs of impact or thermal related damage when viewed thru the exhaust duct outlets. Random pieces of dirt, debris, and similar vegetation were lying inside the exhaust collector support. The support sustained inward crush damage on its right hand side as well as at the tunnel area. Oil wetting was noted at the 3:00 quadrant of the 4th-stage power turbine wheel corresponding to the orientation of the engine and wreckage at the crash site.

Continuity of the N1 rotor could not be initially established. Inward crush damage to the starter generator shroud was restricting rotation of the cooling fan. Additionally, the damage to the lower compressor case half was also preventing rotation.

The starter generator, fuel pump, and both compressor case halves were removed, which enabled full continuity of the N1 rotor back through to the gas generator turbine. A length of plastic tie wrap was inserted into the outer combustion case through the fuel nozzle port up to the 1st-stage gas generator turbine wheel. Turning the compressor rotor by hand resulted in movement of the tie wrap indicating rotation back to the



4th-Stage Power Turbine & Exhaust Collector Support

gas producer turbine. Rotation felt mostly smooth and quiet. The N2 rotor remained locked when attempting to rotate through at the 4th-stage turbine wheel. No further disassembly of the engine was attempted in order to assess the N2 rotor lock up.

The flex hose between the horizontal turbine fire shield check valve and the fuel spray nozzle was removed prior to removing the nozzle. There was no evidence of fuel in the hose. The fuel spray nozzle was removed and inspected. There was no evidence of obstruction in the fuel spray nozzle inlet. The nozzle tip appeared clean with no discernible evidence of coking or soot. The nozzle was not further disassembled.

The engine fuel pump filter was removed and inspected. There was no evidence of fuel in the filter bowl and the filter appeared clear and clean with no sign of dirt or debris. The fuel pump was partially fractured at its connection with the gearbox.

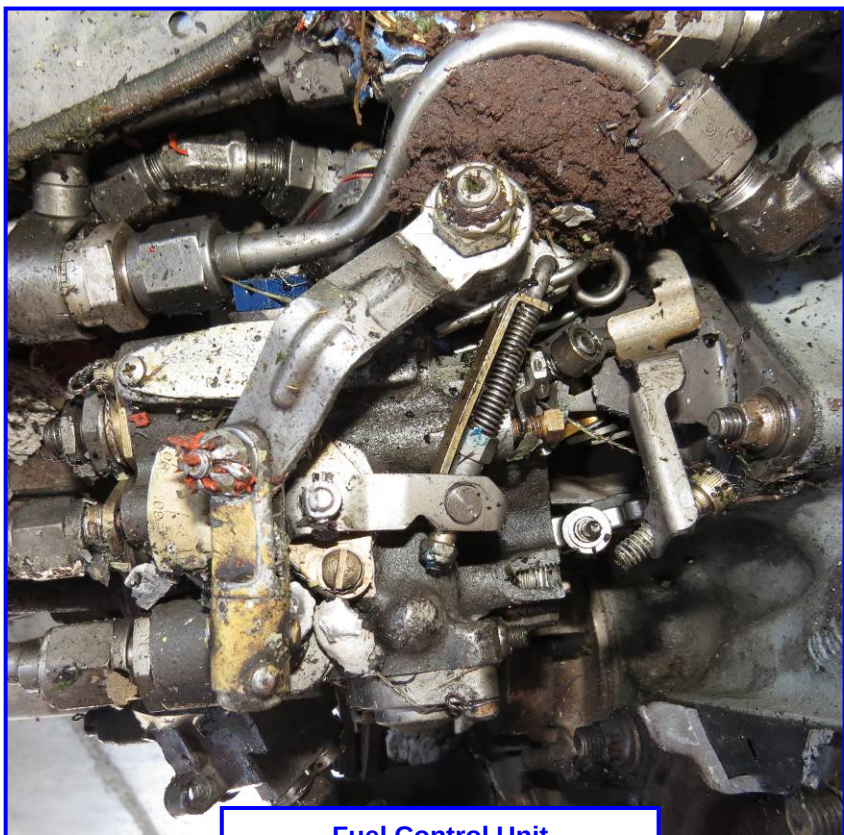
In the process of removing the fuel pump, the outlet tube from the pump to the fuel control unit dispensed approximately 1 teaspoon of clean, clear fuel. The fuel pump drive shaft was intact and remained with the pump assembly. The pump turned at the input drive shaft with hand pressure.

The Fuel Control Unit (FCU) was heavily damaged particularly at its connection with the gearbox. The FCU housing had fractured in multiple locations at the mounting flange. Several of the internal components including the rotating flyweight assembly were exposed.

The airframe linkage up to the FCU input arm was fractured. The actuation arm on the FCU could not be rotated using hand pressure and the FCU pointer was positioned at the "0" mark.



Fuel Spray Nozzle



Fuel Control Unit

The Power Turbine Governor (PTG) was fractured at its mounting flange connection with the gearbox. The PTG actuation arm was over-rotated beyond the maximum stop position from impact forces. The linkage between the trim actuator and PTG input arm was fractured. The actuation arm on the PTG could not be rotated using hand pressure. The PTG pointer was positioned at the "MAX" mark on the scale and was prevented from further rotation by the safety-wire locking one of the mounting bolts on the PTG housing flange.

The magnetic chip detectors were removed and inspected. Both chip detectors were void of ferrous metal debris. The upper chip detector did contain a dusty layer of rust colored, crusty debris over the tip and body surfaces. The engine pressure oil filter was removed and inspected. The filter and housing were oil wetted and the filter appeared clean and clear of contamination inside the pleats. The oil filter housing on the gearbox was approximately 2/3 full, the oil appeared normal in color and clarity with no indication of suspended debris. The airframe auxiliary engine oil filter bypass indicator was not extended. The filter assembly was not disassembled and inspected further.



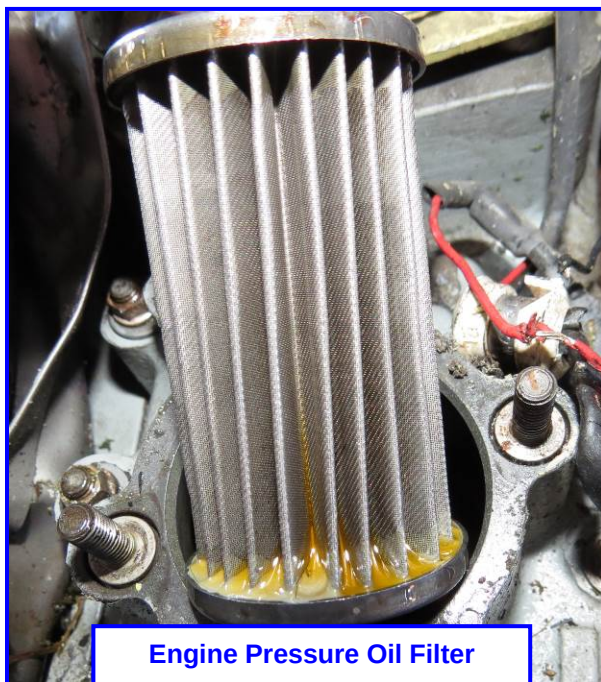
Lower Chip Detector



Upper Chip Detector

The oil tank was breached and heavily damaged from impact and crush forces as well as extensively burned in the post-crash fire. There was no presence of residual oil remaining in the tank.

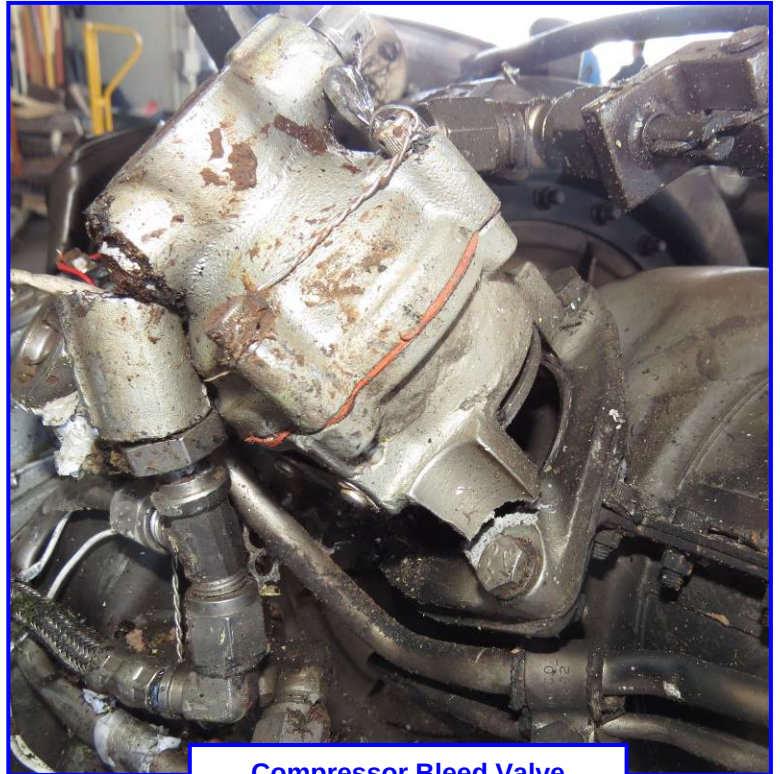
The main oil supply, scavenge, and vent hoses from the gearbox to the aft firewall were intact and connected to their respective fittings at the aft firewall connections. Several of these lines experienced fracture damage at their gearbox connections points. Small amounts of residual oil drained from the pressure and scavenge lines upon removal.



Engine Pressure Oil Filter

The bleed valve was heavily compromised from impact damage. The valve body had fractured adjacent to the bolt flange and the bleed air off-take connection was broken at the top of the valve housing. The poppet valve could be moved using hand pressure.

The aircraft was equipped with an inlet particle separator (IPS) as part of the forward induction cowl. Although the entire cowling had liberated in flight, the inlet and outlet of the IPS was visually unobstructed from any noticeable signs of foreign debris.



Compressor Bleed Valve

Engine Maintenance and Records

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE-830577	6887190	Unknown	9,337.1
Gearbox	CAG-27089	23001923	Unknown	Unknown
Compressor	CAC-34285	6890550	Unknown	Unknown
Turbine	CAT-38569P	23038241	270.4	9336.9
Governor	BR37766	23057870	Unknown	Unknown
Fuel Control	303972	23065104	Unknown	Unknown
Bleed Valve	FF22016	23053176	Unknown	Unknown
Fuel Pump	T4190	6899253	Unknown	Unknown
Fuel Nozzle	AG-12239	23077068	Unknown	Unknown

Summary of Findings

- There was no evidence of pre-impact fire, damage or malfunction of the engine.
- The engine displayed significant impact damage along the entire length of the right hand side.
- Several accessory drive components showed fracture damage at their gearbox connections.
- There was evidence of engine and drive train rotation at the time of the event.
- Continuity was established for the N1 rotor system. The N2 rotor assembly remained locked. Further disassembly of the engine to assess N2 continuity was not accomplished.
- Control continuity could not be established to either the power turbine governor or fuel control unit due to the severity of impact damage.
- Available evidence suggests the engine was producing power and responding to throttle inputs as indicated by the following conditions:
 - Rotational scoring on the main rotor transmission isolation mount from contact with fractured KAFlex® forward output drive shaft.
 - Fracture damage to the KAFlex® forward shaft flexure links.
 - Rotational scoring on compressor stage 2 & 3 blade tracks.