

04/05/2022

CEN22LA146 - N500MZ NTSB Examination Report

Present: Luis Deliz (FAA Des Moines FSDO – Principal Avionics Inspector), Joan Gregoire (MD Helicopters – Air Safety Investigator), Nick Shepler (Rolls-Royce – Air Safety Investigator), Chris Thresher (Winco Powerline Services – Pilot), and Ryan McEwen (Winco Powerline Services – Mechanic) at the Arthur N. Neu Airport (CIN), Carroll, Iowa on 04/05/2022.

Airframe (Hughes 500D, Serial Number 0159D)

The fuselage was observed on the hangar floor leaning toward its RH side; the RH landing gear appeared fracture-separated at the top end of the forward and rear struts.

The forward fuselage, including the door frame assemblies, canopy framework, and acrylic panels, was primarily intact. The lower fuselage, including the center beam, floors, bulkheads, and seat support structures, exhibited damage primarily to the RH seat support structure. The LH seat pan and seat support structure were unremarkable; the RH seat pan was slightly deformed, and the seat support structure was deformed and exhibited a rupture on the forward-facing wall near the floor. The aft fuselage, including the mast support structure, engine air inlet installation, turtledeck (lower section), and aft fuselage boom fairing, exhibited damage to the aft engine air inlet fairing and the boom fairing tail cone, both of which were mostly fracture-separated from the aft fuselage. The mast support structure and turtledeck appeared undamaged.

The tail boom was fracture-separated from the fuselage and exhibited damage consistent with a main rotor blade strike.

The empennage was fracture-separated from the tail boom and exhibited damage consistent with a main rotor blade strike. It remained primarily intact. The upper vertical stabilizer exhibited a horizontal dent on its lower leading edge and a diagonal crease from the forward upper RH side to the aft lower RH side.

The helicopter was equipped with skid-type landing gear. The LH landing gear remained attached via the forward and aft landing gear struts, braces, and dampers; however, the LH landing gear appeared slightly splayed outward. The RH landing gear was fracture-separated from the forward and aft landing gear struts just below the strut elbows. The RH aft strut was also fracture-separated at the strut elbow and below the fillet; the RH forward strut was fracture-separated just above the step. Both the RH forward and aft dampers were fracture-separated from the struts.

Survivable space was maintained; the cockpit enclosure was unremarkable, the acrylic windshields were intact, and doors and door frames were unremarkable. The RH cockpit door acrylic window was cracked, and a piece of acrylic was missing. The cockpit was configured for LH command. The RH cyclic and collective were not present, but the RH pedal arms were present, and zip tied together. The pilot's seat

belt hook assembly was observed disconnected from the inboard attach fitting; the cotter pin remained in place in the hook assembly, however, the spring-loaded safety appeared splayed.

The cabin was unremarkable.

Flight control continuity was confirmed from the LH cyclic control stick and collective control stick up to the main rotor hub assembly. Anti-torque control continuity was confirmed from the LH anti-torque pedals back to the fracture in the tail rotor control tube, and from the fracture back to the tail rotor assembly.

The twist grip on the LH collective control stick was rotated by hand and the power lever angle (PLA) needle on the FCU moved accordingly; however, when the twist grip was rotated to the OFF position, the PLA needle did not indicate that it was in the OFF position. Impact damage to the lower RH side of the cockpit appeared to limit full movement of the control cable. The LH collective control stick was raised and lowered, and the power turbine governor pointer moved accordingly.

Powertrain continuity was confirmed. The main transmission drive shaft was rotated by hand and corresponding movement was observed throughout the powertrain, including the oil cooler blower, main rotor hub, and tail rotor drive shaft. The tail rotor drive shaft was fracture-separated at the forward fracture of the tail boom. The aft portion of the tail rotor drive shaft was rotated by hand and rotation of the tail rotor blades was observed. The overrunning clutch was removed and actioned by hand and it functioned appropriately. Fluid was observed through the sight glasses of both the main and tail rotor transmissions. The main transmission chip detectors were removed and no visible ferrous particulate matter was observed on either one. The tail rotor transmission chip detector was removed, and no visible ferrous particulate matter was observed.

The main rotor blades had been removed from the helicopter. All five main rotor blades appeared bent to varying degrees just outboard of the doublers. The blue blade was fracture-separated about 12 inches outboard of the doublers; the remaining portion of the blade exhibited warping, trailing edge separation, aft blade tip deformation, and a slight upward curvature. The trailing edge damper attachment was fractured and found attached to the blue damper. The white blade exhibited minimal damage. The red blade exhibited minimal damage; however, the aft blade tip appeared damaged. The green blade exhibited minimal damage. The yellow blade exhibited warping, trailing edge separation, aft blade tip deformation, and an S-shaped curvature.

The main rotor dampers remained attached to the pitch housings. The dampers appeared to have been disconnected from the trailing edge of the blades when the blades were removed, except for the blue damper, which had retained a portion of the blue blade trailing edge damper attachment. The pitch links remained attached at both ends and no notable bending of the pitch rods was observed. The main rotor hub exhibited minor damage.

The tail rotor system was examined and found to be unremarkable.

The fuel drain valve on the belly of the helicopter was removed and over 30 gallons of fuel were drained from the fuel cells. The LH fuel cell access door assembly was removed and the fuel shutoff valve was observed in the closed position, which corresponded to the position of the fuel shutoff control in the cockpit. The fuel shutoff control was actioned by hand and the fuel

shutoff valve moved accordingly. The LH fuel cell cover was lifted slightly to observe the engine start pump, its wiring, and the float arm and float; no anomalies were observed. Following the removal of the LH fuel cell cover, the engine start pump was removed and both fuel inlet ports appeared free of debris. The pump electrical wires were connected to a truck battery and the pump was found to be operational.

Engine (Rolls-Royce M250-C20R/2, Serial Number CAE295832)

The engine remained securely attached to the respective mount struts on the engine accessory gearbox. The engine compartment area exhibited no apparent damage.

The output drive shaft coupling forward of the freewheeling unit was securely attached at the 4-bolt mount flange.

Cockpit controls up to the power turbine governor (PTG) & fuel control unit (FCU) were continuous to the control cable rod ends.

Airframe damage prevented the FCU from achieving flight idle "100" or max to the "0" or off position from the twist grip throttle on the cockpit collective lever.

Cockpit collective pitch control to the PTG control lever was verified based on helicopter settings.

A vacuum check of the airframe to engine fuel system was successfully performed with no anomalies noted.

Both N1 and N2 rotors could be rotated by hand and were smooth and quiet.

Continuity was confirmed throughout the N1 rotor system from the compressor rotor to the starter-generator cooling fan.

Continuity was confirmed throughout the N2 rotor system from the 4th-stage power turbine wheel to the main rotor & tail rotor driveshaft.

All engine B-nuts and fittings were checked by hand for proper torque.

All B-nuts with the exception of the Pc tube connection at the FCU were found to be at least hand tight & most marked with torque paint.

A thorough examination of the engine, including a test cell run, will be conducted at a Rolls-Royce Authorized Maintenance Center the week of April 18, 2022.

Other

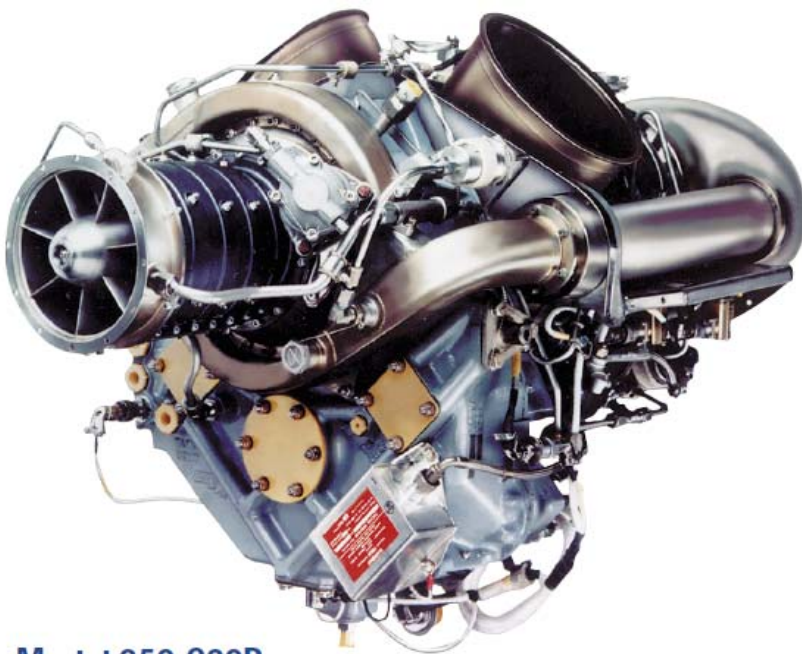
The various maintenance records, for the airframe and the engine, were documented.



Rolls-Royce

Engine Investigation Report

**Rolls-Royce Corporation
Model 250-C20R/2
Engine CAE-295832**



Model 250-C20R

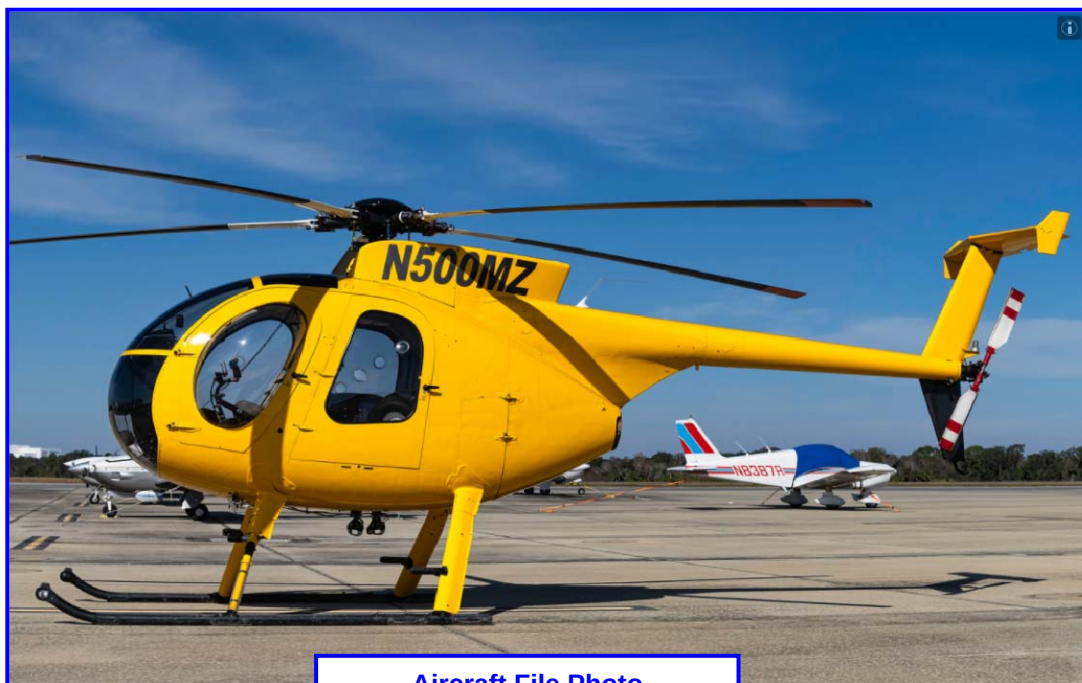
**Nick Shepler
Air Safety Investigations**

**Winco Powerline Services, Inc.
De Soto, Iowa**

**Accident date: 17 March 2022
Wreckage exam date: 5 April 2022
Engine exam date: 20 April 2022
Report date: 29 April 2022
NTSB Case: CEN22LA146**

Background

On March 17, 2022, about 1430 central daylight time, a Hughes 500D (MD-369D), operated by Winco, Inc., registration N500MZ, was substantially damaged when it was involved in an accident near De Soto, Iowa. The commercial pilot sustained minor injuries. The helicopter was operated as a Title 14 Code of Federal Regulations Part 133 external load flight.



Aircraft File Photo

The aircraft was recovered to a general aviation hangar used by Winco Powerline Services, Inc. at the Arthur N. Neu Airport (KCIN) in Carroll, Iowa for further examination.

This report presents the observations made during the investigation.

Accident Flight

NOTE: The author of this report did not attend the accident site examination but was provided details of the scene as well as the accident flight by the NTSB-IIC.

The mechanic reported that on March 5, 2022, the current engine was installed in the helicopter and that the work was performed in accordance with the Rolls-Royce M250-C20R-Series Operation and Maintenance Manual. The engine had arrived with all the accessories previously installed except for the starter generator. The tach generators, fuel control, governor, fuel nozzle, and bleed valve were already installed before they received the engine. The helicopter had several abnormal starts after the installation work and the maintenance team kept troubleshooting the abnormal starts.

On March 16, 2022, the fuel control unit was removed from the previously removed engine and was installed on the current engine for troubleshooting purposes. After the fuel control unit was installed, the fuel system was purged of air, a Pc system leak check was performed with the engine running, and a ground run was performed.

On the day of the accident, the pilot performed a fuel sample check and the preflight checks with no anomalies noted. The pilot aborted the first start due to a high turbine outlet temperature (TOT). The mechanic adjusted the acceleration settings, and the second start was within TOT limitations. The pilot then departed for the landing zone.

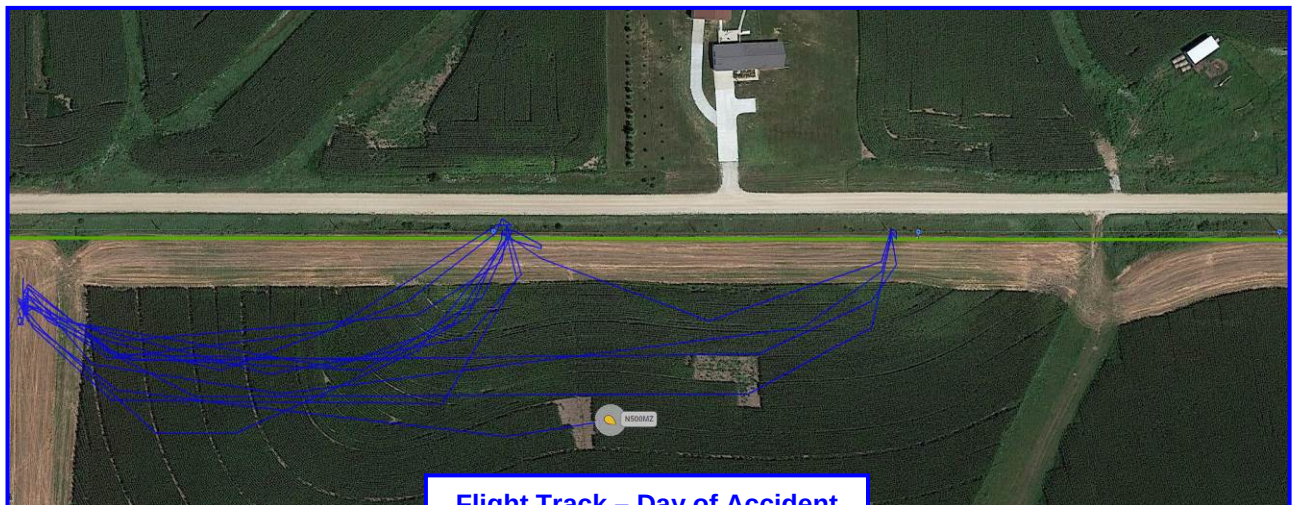
While conducting long-line operations and when flying to a powerline structure the helicopter sustained a partial loss of engine power. The helicopter was at 90ft above ground level (AGL) and about 30kt forward speed; the pilot lowered the collective to enter an autorotation. He was unable to point the helicopter into the wind because a powerline was in the direction of the wind, so the aircraft was subjected to a 20kt crosswind from the north (the pilot's left side). At that altitude and airspeed the pilot was unable to build much inertia in the main rotor system and the helicopter impacted a muddy grass hill. The helicopter came to rest on its right side. After the helicopter came to rest, the pilot noticed the engine was still running at what he described as, "at a slow run, less than idle." The pilot performed an emergency shutdown and was able to egress from the helicopter without further incident.

The helicopter sustained substantial damage to the fuselage, the main rotor system, and the tail rotor system. The helicopter was recovered from the accident site for a future examination of the airframe and the engine. During the recovery from the field, it was noticed by the operator that an airline on the governor to the fuel control was found not attached, via the B-nut. It appeared the B-nut had backed away to the elbow of the line.

The Rolls-Royce M250-C20R-Series Operation and Maintenance Manual provide a warning that states: Failure to properly install, align, and tighten fuel, oil, and air fittings and tubes could result in an engine failure.



Aircraft at Accident Site



Flight Track – Day of Accident

Aircraft Information

Model	MD-369D
Serial Number	0159D
Registration Number	N500MZ
Airframe Total Time	15,143.2 Hours (at time of accident)
Hobbs	15,143.2
Last Inspection (100-Hr)	18.5 Hours (9-Mar-2022)

Engine Information

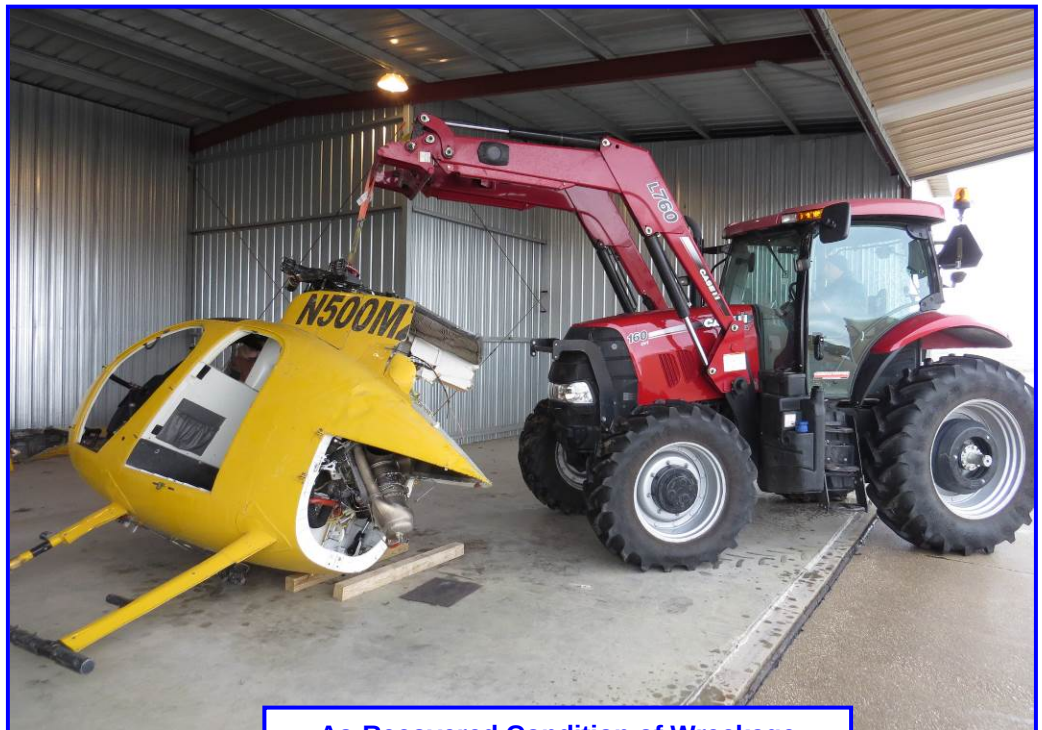
Engine Model	Rolls-Royce 250-C20R/2
Rating:	450 HP
Serial Number	CAE-295832
Engine Total Hours/Cycles	3,042.2 Hours/1,564 Cycles (at time of accident)
Last Inspection (150-Hr)	32.5 Hours (5-Mar-2022)

Wreckage Examination Details

Recovery examination was conducted 5-April-2022 at a general aviation hangar used by Winco Powerline Service, Inc. at the Arthur N. Neu Airport (KCIN) in Carroll, IA. The NTSB did not participate in the recovery examination. Federal oversight was provided by members of the Des Moines, Iowa FAA-FSDO. Additional party members included Rolls-Royce Air Safety, MD Helicopters Flight Safety, & representatives from Winco Powerline Services, Inc.

The aircraft sustained substantial damage upon impact fracturing the entire right hand skid and strut assembly. Prior to engine removal, the aircraft was positioned upright using a tractor and supported with aircraft jacks at fuselage support points. This allowed the fuselage to sit level for the purposes of the wreckage examination & engine removal.

The tail-boom and tail rotor driveshaft were severed approximately 36" forward of the tail-rotor gearbox & aft stabilizer. The tail rotor drive shaft exhibited signs of low speed rotational scoring & torsional bucking/fracture at the severed location.



As-Recovered Condition of Wreckage

The engine remained within the engine compartment. All three mount struts were secure with no sign of bending, fracture, or lateral displacement. The engine exterior did not reveal any obvious signs of damage from impact forces, internal engine failure, or evidence of fire.

The output drive shaft coupling forward of the freewheeling unit was securely attached at the 4-bolt mount flange. The engine to main rotor transmission shaft was intact at its respective connection points & exhibited no visually noticeable damage. Functionality of the freewheeling unit was confirmed when turning the main rotor head & verifying no rotation at the 4th-stage turbine wheel.



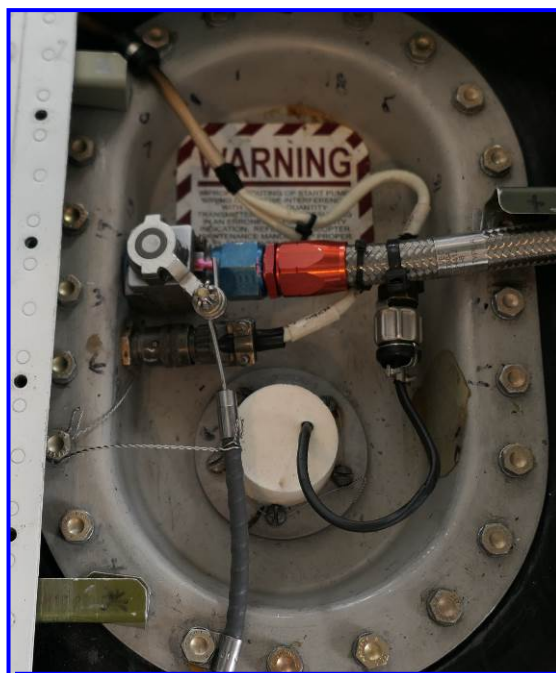
Engine Compartment – General Condition

Collective pitch continuity to the Power Turbine Governor (PTG) was confirmed when moving the cockpit control within its full travel range. Likewise, full stop-to-stop travel of the control arm was confirmed at the PTG following disconnection of the input linkage.

Throttle continuity to the Fuel Control Unit (FCU) was confirmed from the collective arm twist grip to the input linkage at the FCU pointer indicator. However, impact damage within the airframe cockpit compartment had compromised (limited) the travel movement from the ground idle position to the off position. Full down (off) travel could be achieved by manually moving the input linkage between the airframe bell-crank & the control arm on the FCU.

Prior to engine removal, a vacuum check of the airframe to engine fuel system was performed. In preparation for the test and per the test procedure, the fuel cut-off was actuated in the cockpit & the FCU was set to the “0” or off position. The fuel supply system was checked for integrity by applying vacuum to the fuel filter bowl upper port. A hand vacuum pump was exercised to apply 10-in.Hg; the vacuum held for the required 2 minutes. The test was repeated at the same settings with no anomalies noted.

In conjunction with the airframe fuel system vacuum check, the airframe fuel tank was accessed to verify functionality of the fuel cut-off valve, condition of the fuel start boost pump, & presence/condition of fuel in the tank. The shut-off valve was reaching its full open/close travel positions via the cockpit push/pull knob control on the instrument panel.



Accessing Fuel Tank – Shutoff Valve

The start boost pump was removed & visually examined. Battery power was applied to the pump following removal and the pump motor could be heard spinning. No obvious anomalies were noted. The tank was drained of approximately 25-30 gallons of clean, clear fuel with no obvious signs of debris. A fuel sample was not collected for further examination.

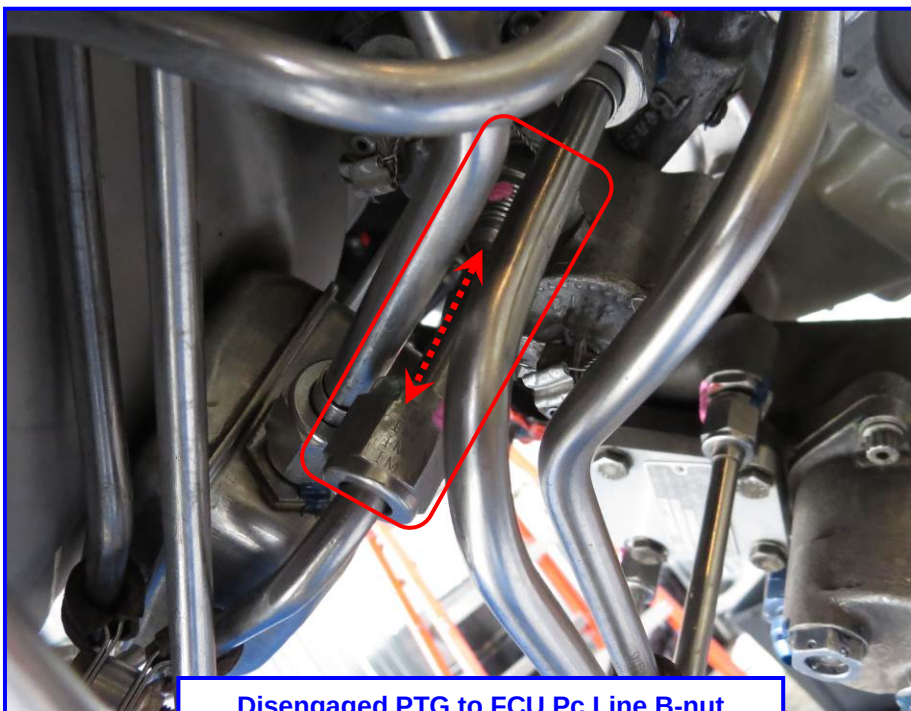
The aircraft was not equipped with an airframe mounted fuel filter. It was fitted with an external engine oil filter adjacent to the lower right portion of the firewall. The bypass indicator on the filter housing was not extended. The filter housing was not opened for examination. The aircraft was fitted with an inlet barrier filter adjacent to the compressor inlet. The filter element appeared clean & free of any notable, random debris.

The engine B-nuts and fittings were checked by hand for proper torque. All B-nuts except for the Pc tube connection at the FCU were found to be at least hand tight and marked with a variety of torque paint colors.

Both N1 and N2 rotors could be rotated freely by hand and were smooth and quiet. Continuity from the power turbine 4th-stage wheel to the power output shaft forward of the freewheeling unit was established. Continuity was also confirmed throughout the N1 rotor system from the impeller to the starter-generator cooling fan.

The upper & lower magnetic chip detectors, engine fuel filter, fuel spray nozzle, and engine oil pressure filter were not removed & examined as this was to be conducted later as part of a more thorough engine examination & prior to engine testing.

The bleed air valve was operated by hand. The poppet valve appeared clean and smoothly travelled its full stroke with no indication of radial movement or binding.

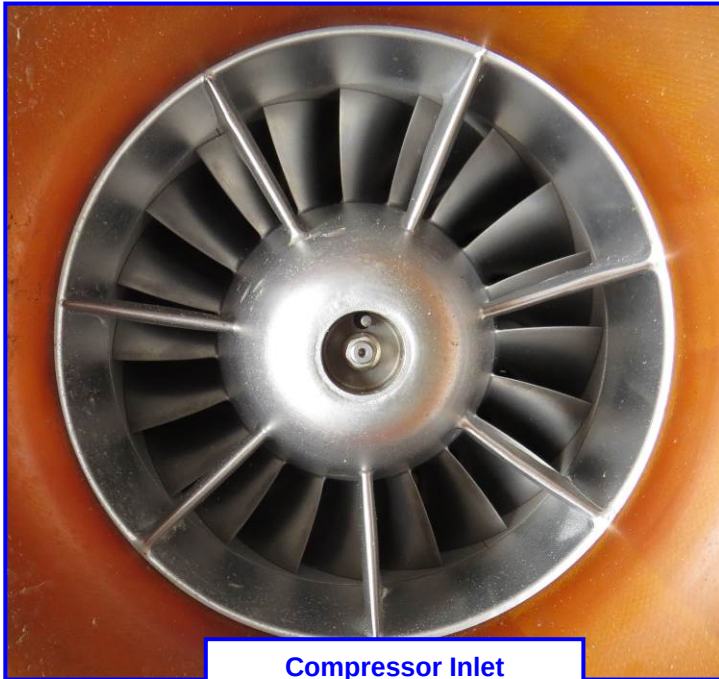


Disengaged PTG to FCU Pc Line B-nut

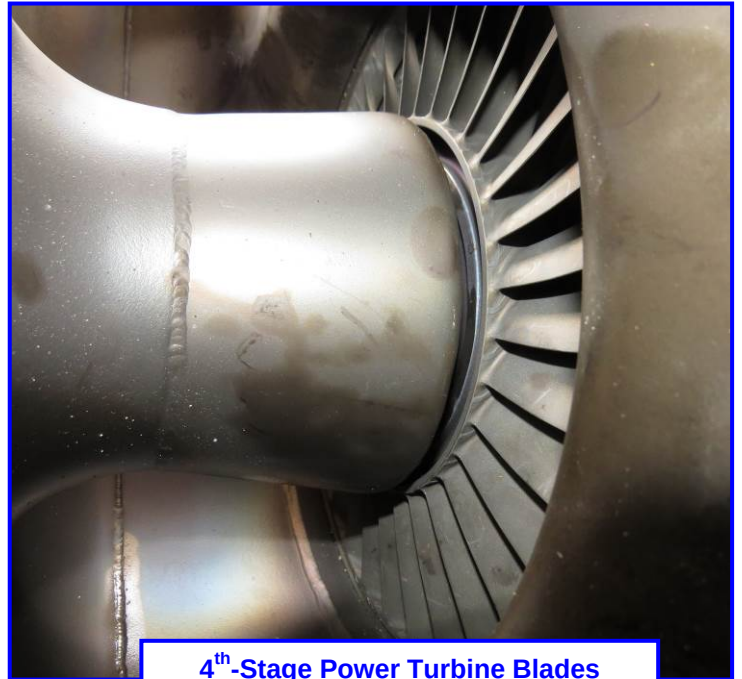


As-Removed Condition of Engine

The 4th-stage turbine blades appeared undamaged when inspected as did the surrounding turbine sections and exhaust plenum. The compressor inlet was also undamaged and exhibited no indication of FOD ingestion.



Compressor Inlet



4th-Stage Power Turbine Blades

Per the direction of the NTSB-IIC, the engine was removed from the airframe and prepped for shipment by removing all airframe specific accessories and protecting various air, oil, & fuel connections as well as the intake & exhaust openings. The engine was placed into a customer supplied shipping container by the party representatives and subsequently transported to Keystone Turbine Services in Coatesville, PA, which is a Rolls-Royce Authorized Maintenance Center (AMC).



Engine Prepared for Shipment

ENGINE EXAMINATION DETAILS

On 20 April 2022, the subject engine was removed from the shipping container & examined at Keystone Turbine Services with regulatory oversight provided by the NTSB. Prior to prepping the engine for test a number of additional investigative actions were performed.



As-Received Condition of Engine

The fuel spray nozzle was removed and visually examined. The external spray surface was uniformly black in color with no carbon or soot build-up. None of the air distribution holes appeared blocked. The nozzle was not disassembled further & was subsequently deemed unremarkable.

The upper & lower magnetic chip detectors were removed & inspected clean of metallic debris. The engine pressure oil filter was not removed and inspected.



Prior to performing the Pc system air leak check, a more thorough assessment of the displaced PTG to FCU Pc air tube B-nut disengagement was performed. The following steps were taken & observations made:

- (1) Both the B-nut & union fitting on the FCU displayed presence of multiple torque paint markings, presumably from prior maintenance. The presence of continuous pink torque paint observed on the intact connections confirms the most recent installation by the length of striping on the union fitting threads. (Figure 1)

Note: For reference in the supporting photos, the most recent torque paint used was pink.

The mechanic stated that attempts were made to remove old torque paint markings but that it can be difficult; particularly in an installed engine configuration.

Note: The M250 C20R-Series Operation & Maintenance Manual cautions in the rigid tube inspection and installation task that all previous torque paint must be removed & re-applied each time the B-nut is loosened and tightened or engine damage can occur.

- (2) The B-nut was threaded down to the point where both ends of the torque stripe were “touching” and in alignment. This is likely what the mechanic observed following FCU installation. The engine exam determined this position to be ½ turn loose. (Figure 2)
- (3) The Pc system air leak check was performed with the B-nut condition shown in Figure 2. A considerable leak was detected.
- (4) The B-nut was run down to the full extent of travel using the OMM specified B-nut torque adapter (wrench) and torqued per the requirements. The nut travelled 5 additional “flats” from its location in Figure 2 to its final torque position. An additional observation was the amount of torque stripe squeeze out upon reaching its full travel. (Figures 3 and 4)
- (5) The Pc system air leak check was performed again with no leaks detected at the subject location.

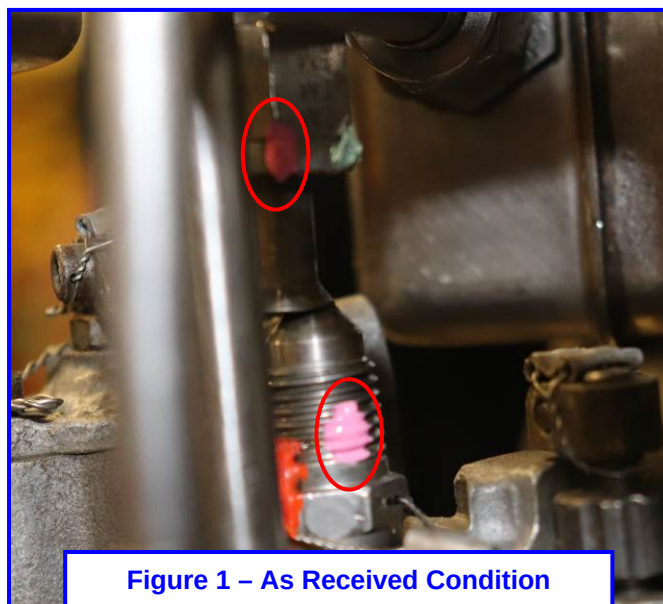


Figure 1 – As Received Condition

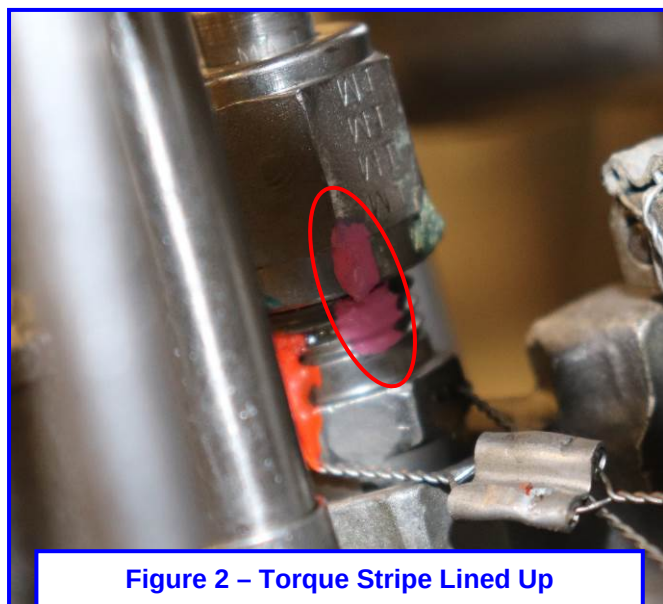


Figure 2 – Torque Stripe Lined Up

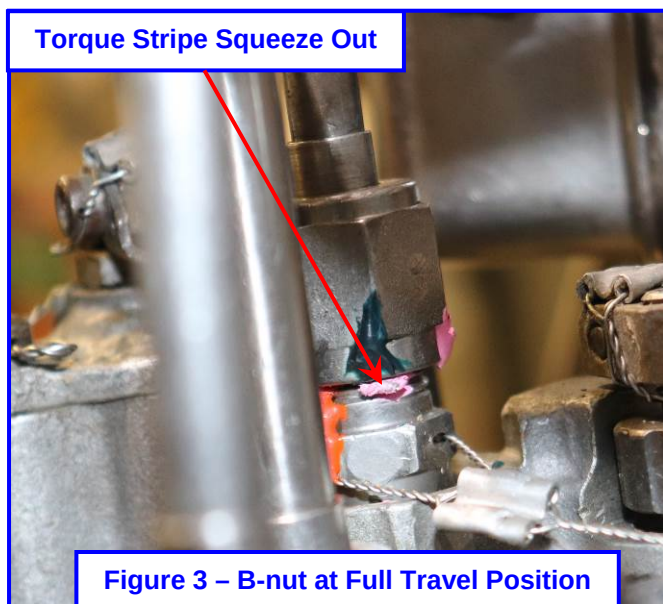


Figure 3 – B-nut at Full Travel Position

The Winco mechanic stated that a leak check was performed with the helicopter running on the ground. No issues were noted during the leak check. The OMM provides an alternate leak check with the engine running at idle condition as an alternate method of inspection if clean filtered compressed air is not available. It is not known if compressed air was available at the time of FCU replacement and post-maintenance air leak check.

Additionally, the mechanic stated that an angle head open end wrench was used to put on the b-nuts. A “crow’s foot” was then attached to a torque wrench, to torque the b-nuts to specifications. The mechanic stated that while torquing the specific B-nut, the FCU was contacted by the torque wrench and a false torque reading was likely provided.

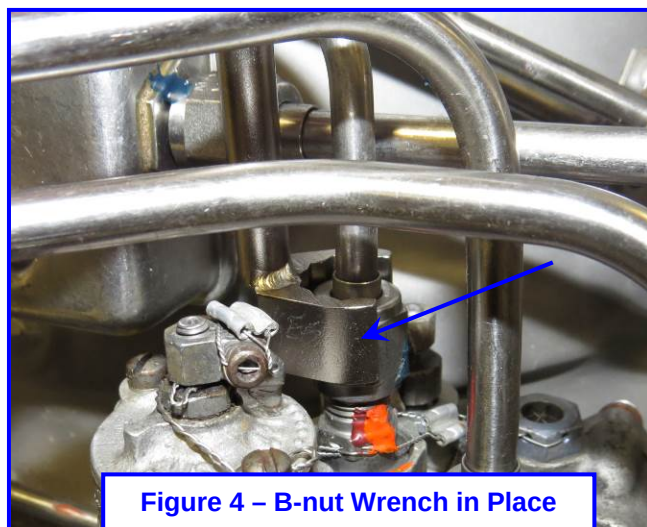


Figure 4 – B-nut Wrench in Place

Upon completion of standard test cell preparedness tasks by Keystone technicians, the engine was considered acceptable to run on the test cell. The engine was installed on a test cell and a 5-point performance test was conducted to new engine production standards (Model M250-C20R), in accordance with Rolls-Royce M250-C20R-Series Overhaul Manual (Publication ref. GTP 5232-3) Revision 22, dated 15 September 2019.

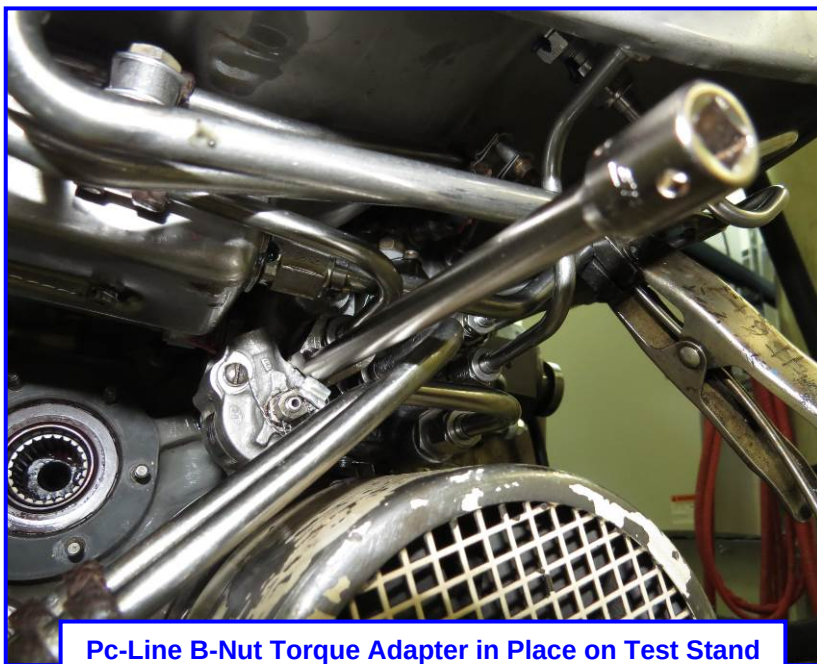


Engine in Test Cell Prior to Run

Prior to performing the standard performance test, the Pc tube B-nut was run down to the same position shown previously in Figure 2. This was intended to replicate its position following the FCU replacement on the aircraft. The engine started & during acceleration, with the starter still engaged, the engine abruptly went to an idle/sub-idle condition. Examination revealed the subject B-nut connection had separated (backed off) at the FCU presenting a similar scenario as that during the mishap flight. The B-nut was refitted & tightened using the OMM specified P/N 23083893 B-nut torque adapter wrench. The engine subsequently performed satisfactorily on the test cell.

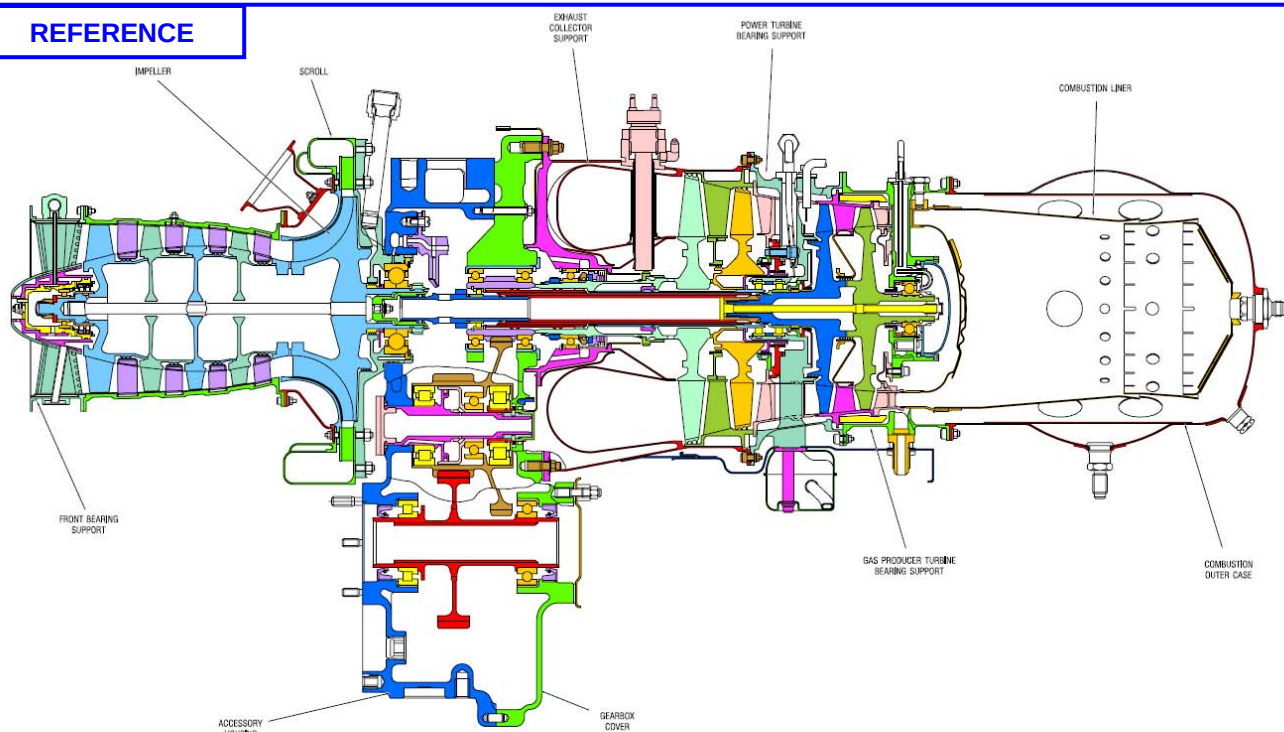
The engine successfully started, ran and shut down. The engine successfully completed ground idle, flight-idle, max-continuous-power and take-off power runs. When corrected for standard atmospheric conditions, the engine yielded performance +22.6% above new-production standards at normal cruise (380 horsepower) and +23.6% above new-production standards at maximum (Take-Off) power (450 horsepower).

The engine then completed “wave-off” max-power transients where the power was reduced to flight idle and then rapidly increased to take-off power. The engine responded normally and responded with maximum power without surging or hesitation. The testing was terminated following successful completion of the wave-off test and power calibration activities.



Pc-Line B-Nut Torque Adapter in Place on Test Stand

REFERENCE



Engine Maintenance and Records

Component	Serial Number	Part Number	TSO (hrs)	Total Time (hrs)
Engine	CAE-295832	23035212	N/A	3,042.2
Gearbox	CAG-15774	23035185	N/A	4,474.2
Compressor	CAC-15112	23050833	New	32.5
Turbine	CAT-40533	23073352	New	32.5
Governor	85240068	M250-10847	New	32.5
Fuel Control	BR52552	23070616	Unknown	1900.9
Bleed Valve	FF54271	23073207	New	32.5
Fuel Pump	T110570	6899253	New	32.5
Fuel Nozzle	AG23361	M250-10603	New	32.5

EXECUTIVE SUMMARY

- There was no evidence of pre-impact fire, damage or malfunction of the engine.
- The engine remained securely attached to the respective mount struts on the engine accessory gearbox. The engine compartment area exhibited no apparent damage.
- Cockpit controls up to the power turbine governor (PTG) & fuel control unit (FCU) were continuous to the control cable rod ends:
 - Airframe damage prevented the FCU from achieving flight idle “100” or max to the “0” or off position from the twist grip throttle on the cockpit collective lever.
 - Collective pitch control to the PTG control lever was verified based on aircraft settings.
- A vacuum check of the airframe to engine fuel system was successfully performed with no anomalies noted.
- Both N1 and N2 rotors could be rotated by hand and were smooth and quiet:
 - Continuity was confirmed throughout the N1 rotor system from the compressor rotor to the starter-generator cooling fan.
 - Continuity was confirmed throughout the N2 rotor system from the 4th-stage power turbine wheel to the main rotor & tail rotor driveshaft.
- All engine B-nuts and fittings were checked by hand for proper torque:
 - All B-nuts with the exception of the Pc tube connection at the FCU were found to be at least hand tight & most marked with torque paint.
 - Discrepancies were noted & confirmed with regards to presence of torque paint striping & subsequent insufficient torque/tightening of the Pc tube B-nut at the FCU.
- The engine performed satisfactorily on the test cell.
 - The “partial B-nut engagement”, presumably similar to that of the mishap event, was configured on the test stand. The engine responded in a manner similar to that of the event.
- All available evidence suggests the engine was capable of producing sufficient power and responding to throttle inputs had the Pc tube been properly connected to the FCU.