



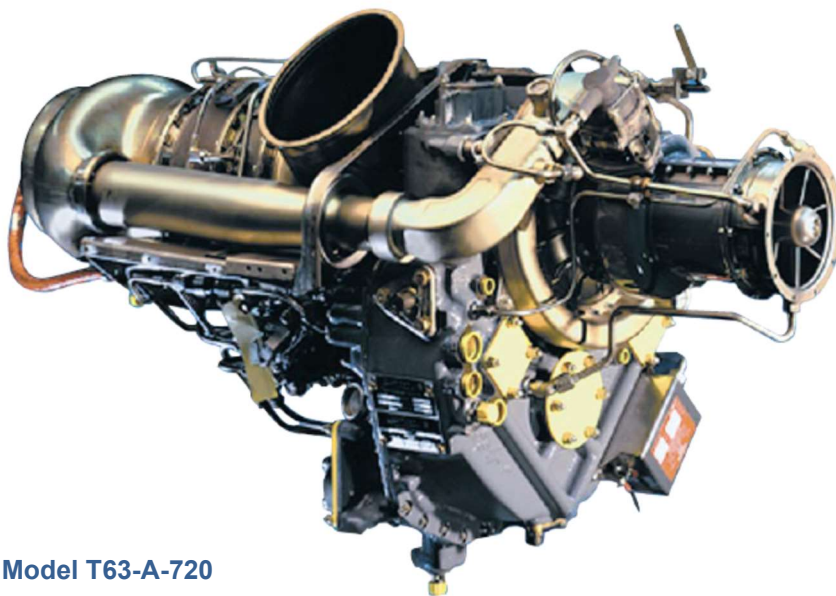
Rolls-Royce

Engine Investigation Report

Rolls-Royce Corporation

Model: T63-A-720

Serial: AE-405882



Model T63-A-720

**Nick Shepler
Air Safety Investigations**

**Owner/Operator: Tri-Rotor Spray & Chemical
Accident Location: Somerton, Arizona**

**Accident Date: 6 February 2023
Wreckage Exam Date: 13 June 2023
Engine Exam Date: 28 November 2023
Report Date: 2 January 2024
NTSB Case: WPR23LA107**

BACKGROUND

On 6-February-2023, at about 2135 mountain standard time, a restricted category Bell OH-58A+ helicopter, N36FA, was substantially damaged when it was involved in an accident near Yuma, Arizona. The commercial pilot sustained minor injuries. The helicopter was operated as a Title 14 Code of Federal Regulations Part 137 agricultural aerial application flight. The pilot, who was the sole occupant on board the aircraft at the time of the occurrence, sustained



minor injuries. The helicopter was substantially damaged. Visual meteorological conditions prevailed for the flight, which operated without a flight plan.

Recovery examination was conducted 13-June-2023 at the operator's facility in Somerton, Arizona. Regulatory oversight was provided by 3 NTSB Regional Investigators. Additional attendees included Rolls-Royce Air Safety and a local FAA-FSDO representative. Maintenance, technical, & engine removal services were provided by a technician employed by the operator.

This report presents the observations made during the investigation.

Aircraft Information

Model	Bell OH-58A+
Serial Number	68-16765
Registration Number	N36FA
Airframe Total Time	9629.8 Hours (at time of accident)
Hobbs	4438.8 Hours
Last Inspection (100-Hr)	56 Hours (performed 27-Dec-2022)

Engine Information

Engine Model	Rolls-Royce T63-A-720 (Commercial: M250-C20C)
Rating:	420 HP
Serial Number	CAE-405882
Engine Total Hours/Cycles	1925.3 Hours (unknown cycles)
Last Inspection (100-Hr)	56 Hours (performed 27-Dec-2022)

ACCIDENT FLIGHT

NOTE: The author of this report did not attend the accident site examination.

The pilot reported that after the night application of chemical insecticide, he landed on the load truck and the chemical hoppers were filled with 50 gallons of water. He maneuvered the helicopter to an open field in low light conditions and expelled the water to rinse out the applicator system. While he was maneuvering about 30 to 40 feet above ground level, with a speed near effective translational lift at 80% torque, the helicopter suddenly started to bounce and yaw. The pilot heard the engine spool down as he held full throttle position and the engine lost all power. The pilot arrested his forward movement by raising the nose. He then leveled the helicopter and started to descend. The pilot raised the collective to control the descent, but the helicopter landed hard. Subsequently, a main rotor blade struck and severed the tail rotor driveshaft and the main rotor blade mast was fractured below the yoke assembly. The main rotor blades & yoke assembly separated from the mast and landed about 100 feet from the helicopter. The aircraft was recovered by the operator and stored at their facility pending further examination.

EXAMINATION DETAILS – GENERAL



As-Recovered Condition of Helicopter

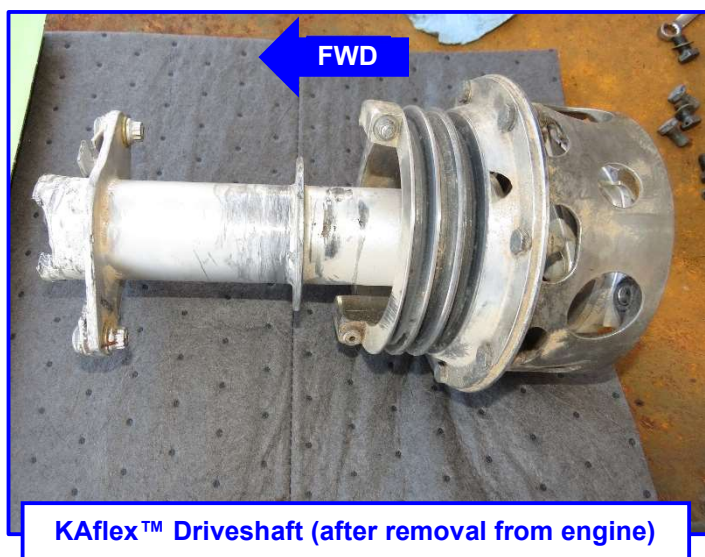
Airframe Relevant Observations

The aircraft sustained damage consistent with vertical impact resulting in a spread of the landing gear skids and bowing of the cross tubes. The aircraft was leaning more heavily to the right indicative of a harder impact on the right-hand skid. The steel tail rotor drive shaft section remained securely attached to the engine gearbox and associated flange connection at the rear vertical firewall in the engine compartment.

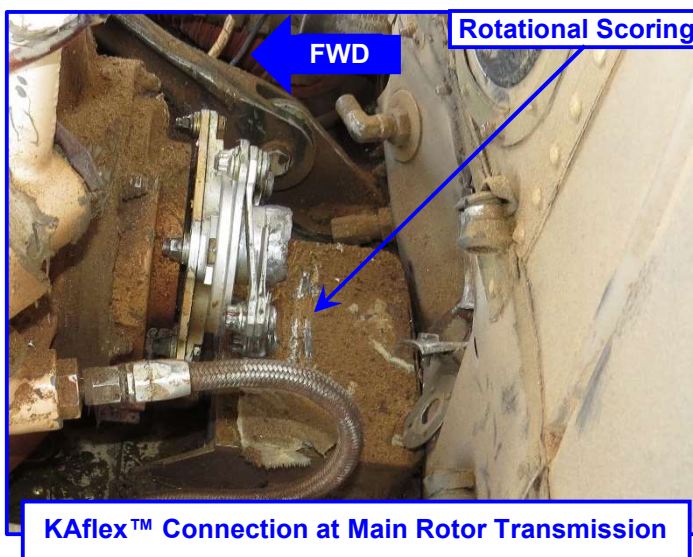


Damaged Tail-rotor Driveshaft & Cover

The KAflex™ driveshaft was fractured in the strap links at the main rotor transmission connection. The shaft remained securely attached within the cage at the freewheeling unit connection on the engine gearbox. Significant rotational scoring was noted in the middle of the shaft as well as on the isolator mount below the front-end connection.



KAflex™ Driveshaft (after removal from engine)



KAflex™ Connection at Main Rotor Transmission

The airframe was equipped with an inlet barrier filter (IBF) that was exceptionally dirty with brown, sand-dust. The aircraft sat outside without inlet covers from the time of the accident to the examination. The IBF bypass door was not open (in bypass mode) nor was the guarded alternate engine intake air switch in the ON position.

EXAMINATION DETAILS - ENGINE

General Condition

The engine remained within the engine compartment. All three mount struts were secure with no sign of bending, fracture, or lateral displacement. Much of the external of the engine was coated with a sand/dirt appearance that may be the result of not being adequately protected during storage awaiting the wreckage examination. The engine exterior did not reveal any obvious signs of damage from impact forces, internal engine failure, or evidence of fire.



Engine General Condition – Left Side

The tail rotor drive shaft remained securely attached to the PTO drive shaft through the engine accessory gearbox & the splined drive adapter at the aft firewall.

A general visual inspection of the engine's various fuel, oil, air, and electrical connections including B-nuts were found hand tight and painted with torque stripe.

Controls

Cockpit controls up to the Power Turbine Governor (PTG) & Fuel Control Unit (FCU) were continuous to their respective control linkage rod ends.

The PTG demonstrated continuity from the cockpit collective control with no influence from aircraft damage. The PTG input lever was capable of full stop-to-stop travel once disconnected from the input linkage and following engine removal.

The FCU demonstrated continuity from the cockpit collective control with no influence from aircraft damage. The FCU input lever was capable of full stop-to-stop travel once disconnected from the input linkage and following engine removal. The pointer indicator on the FCU was initially documented at the approximate 60-70% location. However, it is unclear if the throttle had been moved from its position at the time of the accident & prior to the wreckage examination.

The compressor bleed valve remained securely mounted to the scroll assembly.

The poppet valve appeared clean and smoothly travelled its full stroke with no indication of radial movement or binding when actuated using finger pressure.



Fuel Control Unit Position – As Noted

Rotors

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 1st-stage blades to the starter-generator cooling fan on the engine gearbox. Continuity was also confirmed throughout the N2 rotor system from the 4th-stage power turbine wheel to the KAflex™ drive shaft assembly and the tail rotor drive shaft. The freewheel unit was tested for proper functionality by checking its interactive rotation with the power turbine N2 rotor. The freewheel unit performed as expected.

Compressor

The compressor front support and guide vanes (struts) were noticeably dirty with sand & dirt deposits likely from the atmospheric conditions exposed to during storage. The guide vane struts & visible compressor blades/vanes were void of any visually noticeable evidence of foreign object damage or high metal conditions.



Compressor Inlet

Turbine

The 4th-stage turbine blades appeared undamaged and void of thermal distress as did the surrounding turbine sections and exhaust plenum.

The exhaust collector support “tunnel” displayed an extensive amount of deposited sand and other random debris.

There was no evidence of oil wetting on the tunnel adjacent to or on the 4th-stage turbine wheel. Random amounts of surface rust or equivalent appearance was noticed on the internal surfaces of the support. Both exhaust stacks were noticeably damaged however, the exhaust collector support & exhaust mounting flanges were unremarkable.



4th-Stage Power Turbine & Exhaust Collector

Oil System

The oil tank filler cap was found securely installed. Following cap removal, the tank appeared to be nearly full to the rim of the filler cap opening. The oil appeared clean and clear with no discernible abnormal odor.

Both upper & lower magnetic chip detectors (MCDs) were removed and inspected. Both appeared clean & free of ferrous metal debris. A normal amount of oil was collected out of both MCD ports on the engine gearbox. The collected oil appeared as described of the oil tank.

The pressure oil filter on the engine accessory gearbox was not removed & inspected during the wreckage exam as it was more thoroughly assessed during the formal engine examination.

During the engine removal process, all engine to airframe interface oil lines including those to & from the oil tank, torque meter oil pressure, & engine oil pressure hoses were checked for presence of oil & blockage. No unusual findings were noted.

The aircraft was not equipped with a scavenge oil filter system.

Fuel System

The master fuel valve lever adjacent to the circuit breaker panel on the ceiling above the pilot's seat was in the ON position. It is unclear if this was the lever's position upon initial examination at the accident site.

It was reported by the operator that the aircraft had approximately 20 gallons of fuel on board at the time of the accident. A visual assessment of the remaining fuel was made after gaining access to the tank once the extended range filler neck was removed. Approximately 5 gallons of clean, clear fuel was drained from the tank to provide an approximate verification of the total fuel on board.

A fuel sample was not collected from the aircraft tank drain at the accident site or during the wreckage examination.

Battery power was applied to the aircraft to assess the functionality of the fuel boost pump as well as the fuel quantity gauge. The boost pump could be heard audibly but no fuel was discharged from the supply lines at the fuel filter or engine pump inlet.

The fuel quantity gauge “flickered” to just above the empty mark upon initial power application but ultimately registered zero fuel on board.



Instrument Panel – Power Applied



Fuel Qty. Gauge – Power Applied

The fuel supply hose from the airframe fuel filter canister to the engine fuel pump inlet was removed. Fuel dripped from the engine fuel pump after the hose was removed & while the aircraft was jostled during engine removal preparations.

The engine mounted fuel filter bowl was not removed & subsequently neither was the engine fuel filter as it was more thoroughly assessed during the formal engine examination.

The fuel supply hose from the outlet of the check valve downstream of the FCU was removed at the fuel spray nozzle. Approximately 1 tablespoon was clean, clear fuel was collected, which is normal.

The fuel spray nozzle was removed & inspected. The spray face (tip) contained uniform light layer of black soot. None of the air distribution holes appeared blocked & the nozzle was visually unremarkable. The nozzle was not further disassembled.



Fuel Spray Nozzle

The airframe fuel filter canister was removed for examination. The assembly was not equipped with a bypass indicator. The canister was full of clean, clear fuel. Fuel was drained from the canister revealing only minor elements of residual debris in the bottom. The internal fuel filter was clean and void of any captured debris within the pleats.



Airframe Fuel Filter Canister



Airframe Fuel Filter

Air System

Visual inspection of the Pc (compressor discharge) system including all plumbing & B-nut connections from the compressor scroll to the PTG & FCU appeared intact & undamaged.

A Pc system pressure check was not completed during the wreckage examination as it was more thoroughly assessed during the formal engine examination.

General

Battery power was applied to the aircraft to check the cockpit annunciation/warning panel. Upon power application, the aural warning horn was noticeably audible, and the following warning lights illuminated: ROTOR RPM, ENG OUT, FUEL BOOST, & DC GENERATOR. All warning lights illuminated when depressing the test button.

The engine was removed from the aircraft with little to no complications & placed in an awaiting shipping container provided by Rolls-Royce Air Safety. The engine was shipped to Arrow Aviation in Broussard, Louisiana for further examination.

Aircraft records including the engine & airframe logbooks, daily service records, and pilot flight logs were provided.



Engine Installed in Shipping Container

ENGINE EXAMINATION DETAILS

On 28 November 2023, the subject engine was removed from the shipping container at Arrow Aviation in Broussard, Louisiana with regulatory oversight provided by the NTSB Investigator in Charge (IIC). Prior to prepping the engine for test several additional investigative actions were performed.



As-Received Condition of Engine

The engine was placed in a turnover stand and rotated upside down while accessing the pressure oil filter in the accessory gearbox. The oil filter bowl was drained into a bucket. Approximately 30 cc of clear, odor free oil was collected in the bucket. Small bits of non-metallic dirt or similar debris was observed in the bottom of the bucket that likely fell from external engine surfaces during the engine rotation.

The pressure oil filter appeared clean & clear with no discernible metallic debris within the pleats. The filter bowl housing in the gearbox was oil wetted and free of any notable findings after the engine was rotated to its upright position.



Engine Pressure Oil Filter

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.



Upper Magnetic Chip Detector



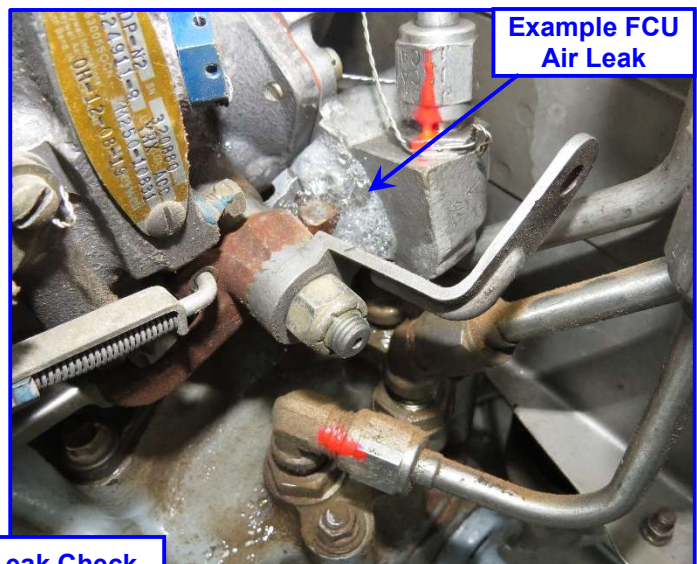
Lower Magnetic Chip Detector

A borescope was used to inspect the overall condition of the combustion liner, nozzle shield, 1st-stage gas producer nozzle, & 1st-stage gas producer wheel (blades). No evidence of residual oil wetting or staining was noted on the 1st-stage nozzle & turbine wheel following the accident sequence & abbreviated engine shutdown or from oil seeping from the No. 8 bearing sump area while the engine was rotated in the turnover stand. None of the associated components exhibited any visually discernible evidence of material loss, liner streaking, or thermal deterioration.

A check of the Pc system was conducted using shop air at the inlet side of the Pc air filter at 80 psi. A soapy water solution was applied to the Pc system B-nuts and rigid tubing. Pressure was then decreased to 20 psi to check for leakage at the governor diaphragm. Minor bubbling was detected at three locations on the fuel control unit however, as the engine test would show, those leaks were not a fuel limiting condition since the engine would later demonstrate being temperature limited during test.



Pc System Leak Check

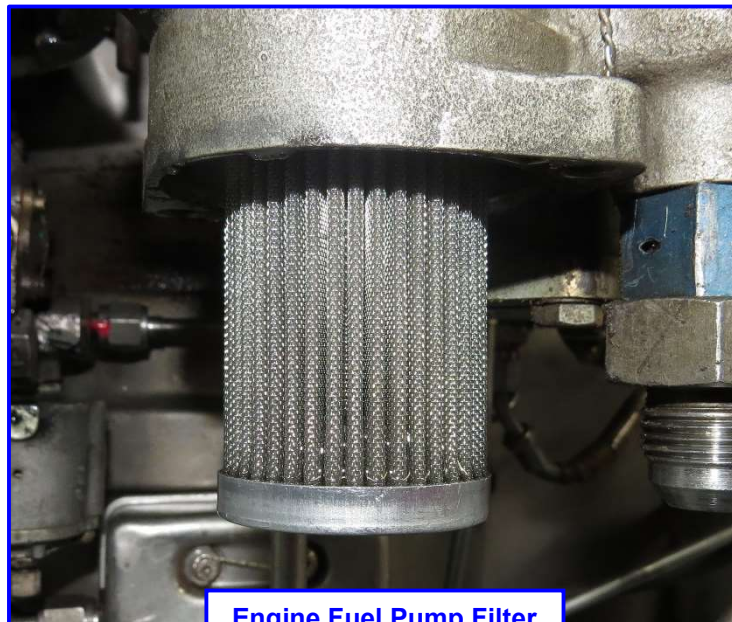


Example FCU
Air Leak

The engine fuel pump filter bowl & filter were removed and inspected. The filter bowl was full of clean, clear, odor free fuel and the filter was clean & free of debris within the pleats.

Upon completion of standard test cell preparedness tasks by the Arrow technicians, the engine was considered acceptable to run on the test cell.

The engine was installed on the test cell and configured to test as per new engine production standards (Model M250-C20B is equivalent to the Military designation T63-A-720), in accordance with Rolls-Royce M250-C20 Overhaul Manual (Publication ref. 10W3) revision 16 dated 1 June 2020.



Engine Fuel Pump Filter



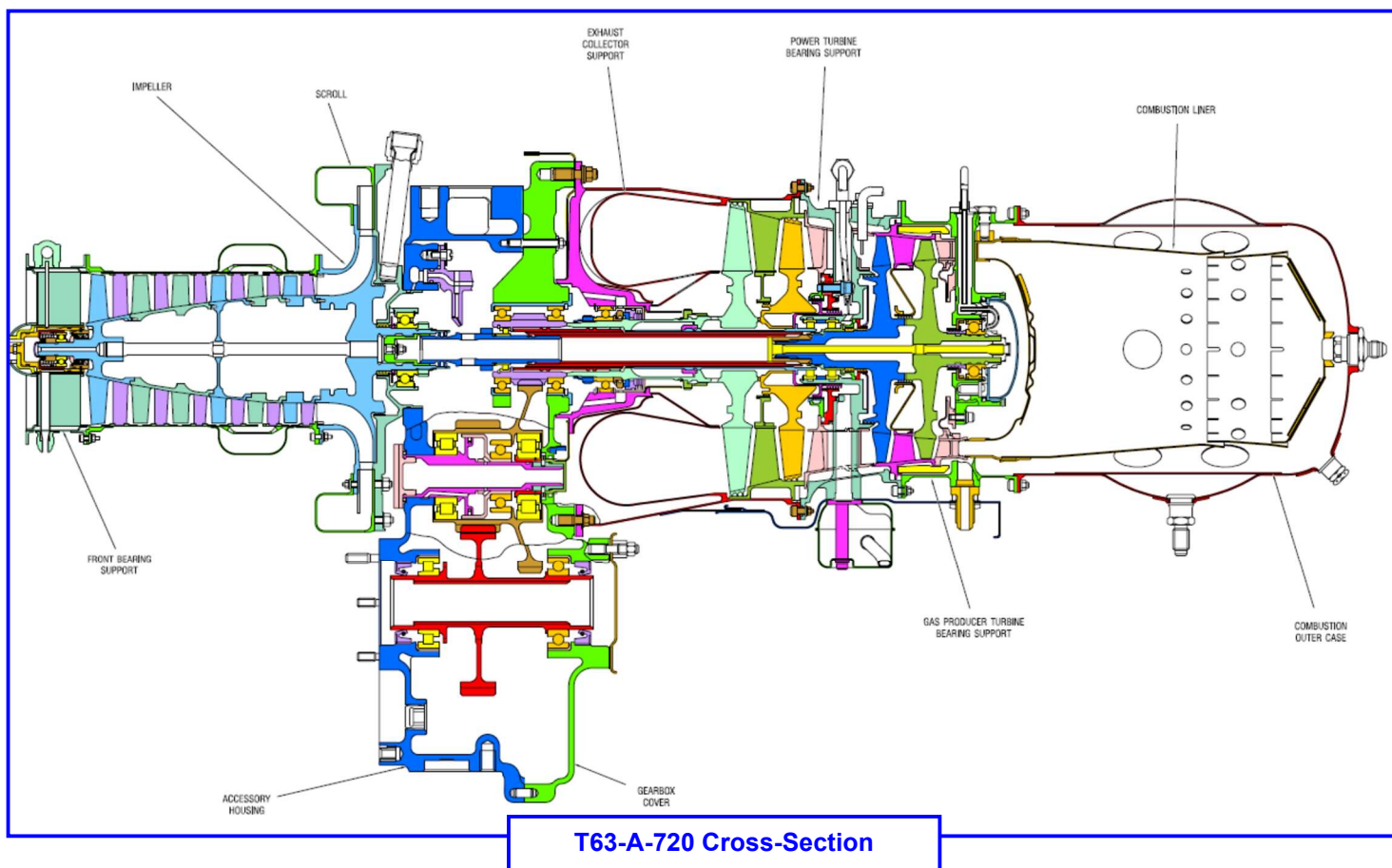
Engine on Test Stand

The maximum output of a Rolls-Royce T63-A-720 engine is 420 SHP but due to the main rotor transmission limits, the engine is flat rated to 317 SHP. The M250-C20 Series Overhaul Manual engine test procedure contains a 5-point performance power calibration test to new engine production standards. This includes operating the engine to its rated horsepower & torque/temperature limits.

The engine successfully started, ran & shut down. When corrected for standard atmospheric conditions, the engine yielded performance -14.3% below new-production standards at “low cruise” (300 horsepower), -11.9% below new production standards at normal cruise (370 horsepower), and -2.6% below new production standards at maximum (Take-Off) power (420 horsepower) achieving a maximum predicted 409 SHP at the specification 1490°F MGT (measured gas temperature). The performance data was reflective of the engine hitting the max allowable MGT limit at each of the 5 calibration points before achieving the specified horsepower value.

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

The engine’s test performance was likely indicative of the noted dirty compressor condition. Additionally, a slight leak was noted during the run at the anti-ice valve that was hard-wired in the closed position by the operator. The burner drain valve on the outer combustion case was also noted as having an air leak during test.



ENGINE MODULE & COMPONENT DETAILS

Component	Serial Number	Part Number	TSO (hrs)	Total Time (hrs)
Engine	CAE-405882	6887191	N/A	1925.3
Gearbox	AE-404455	Unknown	3255.6	5729.6
Compressor	CAC-34131	6890550	2782.5	8800.7
Turbine	AT-17676	23038244	586.9	2313.0
Governor	BR39777	M250-10879	958.9	Unknown
Fuel Control	320880	M250-10831	958.9	Unknown
Bleed Valve	FF49772	23053176	958.9	Unknown
Fuel Pump	T106783	6899253	1521.9	Unknown
Fuel Nozzle	2901	M250-10603	958.9	Unknown

SUMMARY OF FINDINGS

- There was no evidence of pre-impact fire, damage, or malfunction of the engine.
- Cockpit controls to the power turbine governor (PTG) & fuel control unit (FCU) were continuous to their respective control linkage rod ends.
- Fuel was present from the airframe filter to the fuel spray nozzle. Approx. 20 gallons of fuel remained in the aircraft tank. Fuel did not circulate from the boost pump using battery power.
- Both N1 and N2 rotors were continuous, could be rotated by hand & were smooth and quiet.
- All engine B-nuts and fittings were checked by hand for proper torque prior to the Pc system leak check. All were found to be at least hand tight & most marked with torque paint.
- The Pc system contained minor air leaks at 3 points on the fuel control unit. These leaks were not “corrected” prior to engine test but were not a fuel limiting factor during test.
- The engine was installed in a test cell with the intent of running a minimum 5-point performance test in accordance with Rolls-Royce M250-C20 Series Overhaul Manual procedures.
 - The engine reached its max. allowable MGT in advance of achieving each of the power calibration points as compared to new engine production standards.
 - The combined effect of the dirty compressor, leaking anti-ice valve, & burner drain valve likely impacted the engine’s performance.