

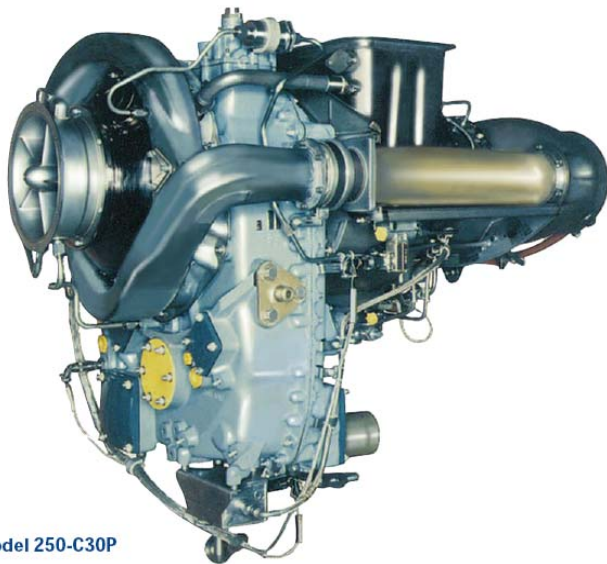


Rolls-Royce

Engine Investigation Report

**Rolls-Royce Corporation
Model 250-C30P
Engine CAE 890152**

**Bell 206L-1
Registration: N1076Y**



Model 250-C30P

**Premier Rotors
Sacramento, CA**

**Nick Shepler
Air Safety Investigations**

**Accident date: 14 June 2016
Investigation date: 1-2 August 2016
Report date: 7 December 2016**

Background

On June 14, 2016, about 1550 Pacific daylight time, a Bell 206 L1 helicopter, N1076Y, was substantially damaged during an auto-rotation landing attempt near Bishop, California, following a loss of engine power during cruise flight. The private pilot and two passengers were not injured. Visual meteorological conditions prevailed, and no flight plan was filed for the cross-country flight that departed Corona Municipal Airport (AJO), Corona, California, at approximately 1320 local time. The personal flight was destined for Mammoth Yosemite Airport (MMH), Mammoth, California.

On 1-August-2016, representatives from the NTSB, FAA, Rolls-Royce, and Bell Helicopter examined the aircraft wreckage at a local aircraft salvage facility (Faeth Aircraft) in Sacramento, California.

The author of this report did not visit the accident site. Information herein was provided by the FAA and NTSB. This report presents the observations made during the investigation.

Accident Flight

The flight departed Corona Municipal Airport with 98 gallons of fuel on board. The helicopter was cruising at 12,000 feet mean seal level (MSL) and after more than 2 hours of flight in greater than anticipated headwinds and turbulence the pilot decided to divert to a local airport in Bishop, CA (BIH, elev. 4124 feet MSL) to refuel.

While the helicopter descended through 10,000 feet MSL, the pilot heard what he described as a “violent explosion” in the engine compartment and immediately felt the helicopter vibrate. He then observed an engine out indication and quickly initiated an autorotation.

During the helicopter's descent to land, the pilot made two attempts to restart the engine, but was unsuccessful. He pulled collective pitch early to avoid landing in a ditch within the perimeter of a landfill facility approximately 3.4 miles from his intended landing at the Bishop airport.

The helicopter impacted the ground hard resulting in substantial damage to the tail boom.

There were no injuries and there was no post-crash fire.



On-Scene Condition Following Accident

Aircraft Information

Model	Bell 206L-1
Serial Number	45380
Registration Number	N1076Y
Airframe Total Time	34947.6 Hours
Hobbs	392.4 Hours

Engine Information

Engine Model	Rolls-Royce M250-C30P
Rating:	650 HP
Serial Number	CAE 890152
Engine Total Hours	17,261.7 Hours
Last Inspection	149.7 Hours (July 1, 2015 – 150/300 hour inspection)
Production Date	29 April 1979

Aircraft Examination

The aircraft was presented for examination outside at Faeth Aircraft in Sacramento, CA. The examination was attended by representatives from Rolls-Royce, Bell Helicopter, NTSB, & the FAA.



On-Scene Condition Following Accident

Airframe Observations

The aircraft exhibited damage consistent with landing on slightly inclined terrain. The tail boom completely severed aft of the horizontal stabilizer. Both main rotor blades exhibited leading edge damage and paint transfer due to contact with the tail boom. The skids did not show evidence of spreading nor was there any other notable damage to the fuselage cabin structure.

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.

Control continuity was established from the collective twist grip to the engine Fuel Control Unit (FCU) and Power Turbine Governor (PTG).

Controls were cycled fully from stop to stop, with no unusual resistance or excessive travel noted during the control movements.



Engine (left-hand side view)

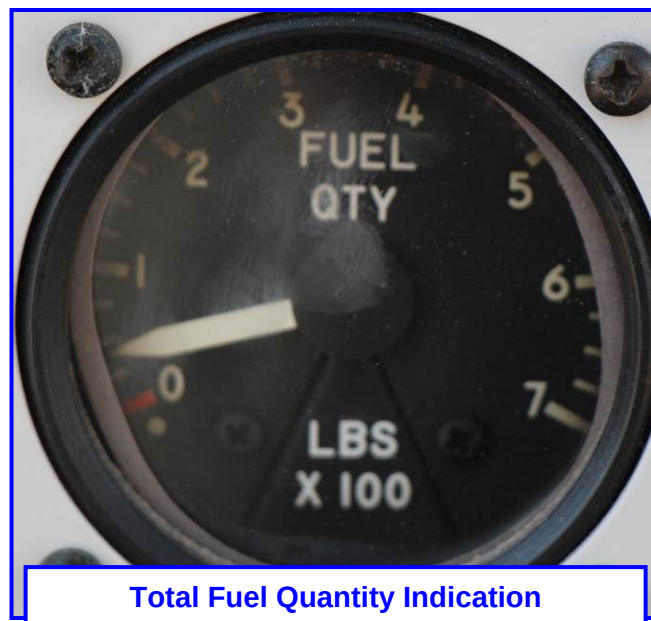
All engine B-nuts and fittings were checked by hand for proper torque. All were found to be at least hand tight and only a select few were marked with torque paint. Examination of the control air tubing did not reveal any evidence of pre-impact damage.

The N2 rotor system could be rotated by hand and was smooth and quiet. Continuity from the power turbine to the power output and tail rotor output shafts was established. The 4th-stage turbine blades appeared undamaged when inspected using a mirror as did the surrounding turbine sections and exhaust plenum.

Access to the compressor inlet could not be achieved at the time of the recovery examination due to lack of adequate tooling to remove airframe components. The N1 rotor system was spun via brief starter engagements using aircraft power. There was no audible or unusually discernible noises could be detected when the rotor coasted to a stop.

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 both airframe fuel boost pumps. Cockpit fuel gauge indicated the total fuel load on board at the time of recovery was approximately 45 lbs (~6.5 gallons). However, a total of 18 gallons was drained from the helicopter during the recovery examination.

The forward fuel cell fuel quantity probe (located in the left hand forward tank) was removed to visually verify presence of fuel. Fuel was present and an attempt to measure the depth of the fuel a makeshift dipstick was inserted in the tank and confirmed approximately 3" height on the stick. The forward tanks are interconnected and each holds 11 gallons.



Total Fuel Quantity Indication

First responder fire department personnel stated they looked inside the main fuel tank to confirm presence of fuel as suggested by the NTSB-IIC. The fire department stated they saw “rivets” at the bottom of the tank suggesting the lack of fuel present in the tank enabled them to see what they thought were rivets. The main tank is comprised of a rubber bladder that seals the entirety of the tank compartment. The lowest point in the tank is where the boost pumps and a host of other fuel system related equipment is mounted. This equipment is secured to the bottom of the tank with screws. Evidence suggests that what the fire department personnel thought were rivets was actually the screws used to mount the boost pumps and other equipment to the tank.

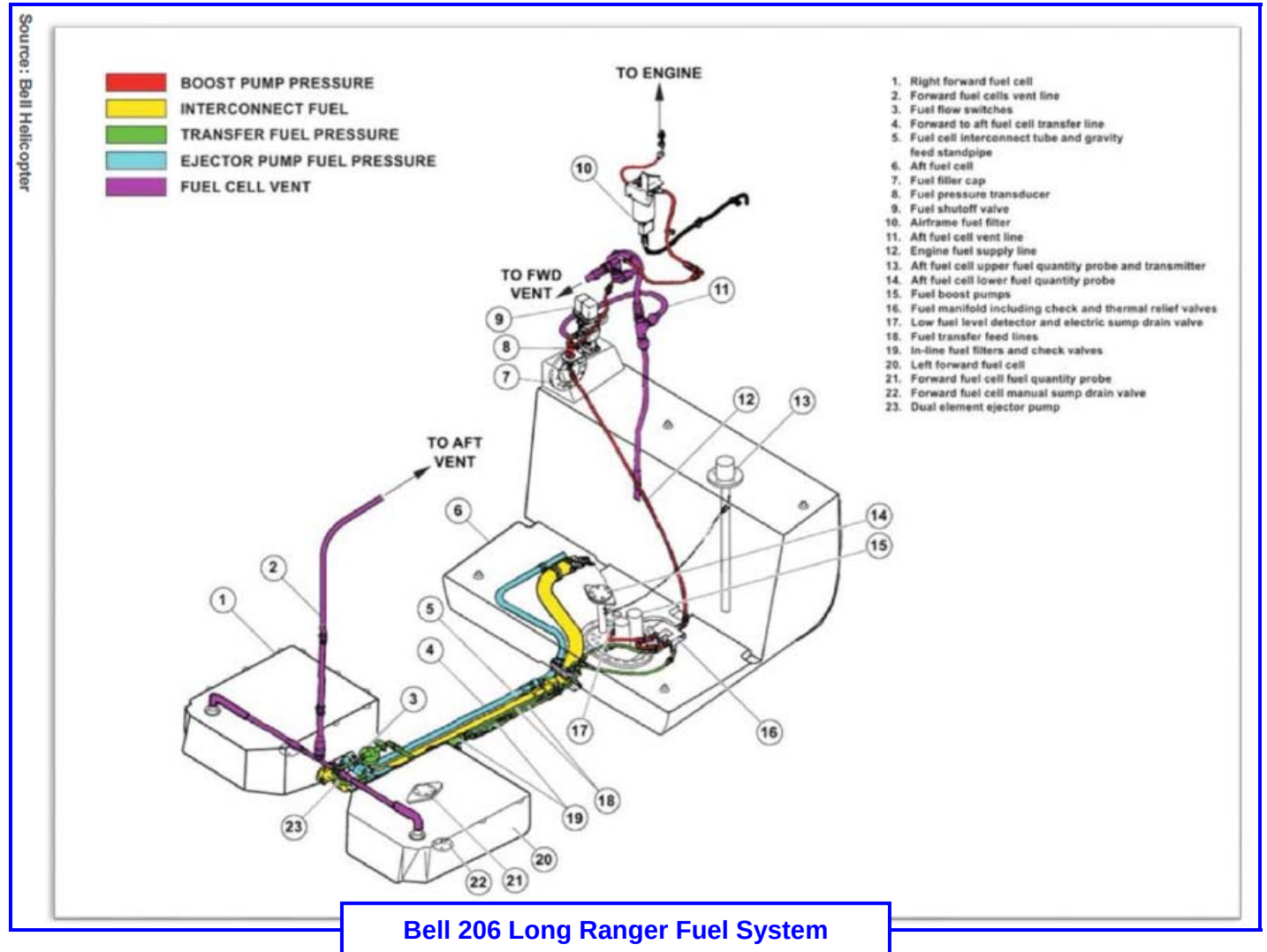
Initial reports stated that the left hand (LH) boost pump circuit breaker was pushed in (ON) and the right hand (RH) boost pump circuit breaker was pulled out (OFF). However, photographs taken at the accident site indicate that both LH & RH boost pump circuit breaker were pulled out. The exact position of the boost pump circuit breakers cannot be confirmed even with pilot statements. Operational functionality of both boost pumps using aircraft battery power was confirmed audibly (sound of boost pumps running), visually via sighting fuel movement in the main tank, and electronically in the cockpit on the fuel pressure gauge.

Boost Pump
Circuit Breakers



Accident Site Position of Overhead Panel
Circuit Breakers

Reference



Fuel is transferred from the forward tanks to the aft main tank via 2 boost pumps (LH & RH) located in the main tank and an ejector pump located between the 2 forward tanks. The flow of fuel through the ejector pump creates suction to transfer fuel from the forward tanks to the main tank. The Bell 206 Long Ranger operations manual requires boost pump operation when flying above 6000 feet.

The airframe-mounted fuel filter was removed and the pleated filter unraveled. Both contained evidence of a brownish-black material.

The fuel line from the airframe 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.

The fuel line from the outlet of the fuel control unit to the fuel nozzle was not removed nor was the fuel nozzle disassembled in consideration of a potential engine test run.

The airframe oil tank filler cap was removed exposing the level of oil in the tank and on the integrated dipstick. The oil level barely registered on the dipstick, well below the ADD level. When removing the lower magnetic chip plug on the gearbox a considerable amount of oil poured out. The decision was made to quickly reinsert the chip plug in order to preserve the remainder of the oil thereby preventing an adequate assessment of the plug for ferrous metal.

The NTSB-IIC recommended deferral of further assessment of the oil system until the engine is prepared for future testing. The upper chip plug and pressure oil filter were not inspected during the recovery examination.

Based on the initial findings, the NTSB and Rolls-Royce recommended the engine be removed without further disassembly and shipped to the Rolls-Royce facility in Indianapolis for detailed examination.

An engine shipping container was delivered to the salvage facility where Bell certified local mechanics, contracted by the NTSB-IIC, removed the engine from the airframe and installed it in the container. The engine was ground transported to Indianapolis for examination.



Airframe Fuel Filter Bowl



Airframe Oil Tank Quantity

Engine Examination

On 19 October 2016, the subject engine was removed from the shipping container at Rolls-Royce's facility in Indianapolis, Indiana with NTSB-IIC oversight. The shipping container was opened and the engine appeared in the same general condition as when it was examined in Sacramento, CA.

There were no covers installed on compressor, open bleed port, or exhaust duct. No evidence of damage or abnormal conditions was noted during the un-crating process. The engine was hoisted by overhead crane and placed into a turnover stand for further examination and preparation for testing ahead.



**Engine As-Received on Container Skid
(with container top removed)**

The engine was shipped to Rolls-Royce with a number of components that had to be removed in preparation for engine testing purposes. Those components included: N1 & N2 tach-generators, starter/generator, and freewheeling unit.

The N1 and N2 tach-generators were removed and a speed handle inserted into the respective drive gears. Both the N1 and N2 rotated freely by hand. The upper and lower MCDs were removed and examined. Both were found to be free of ferrous debris.

The compressor inlet appeared clear of any debris but was noticeably dirty with a build-up of oil and dirt (sludge) around the back edge of the compressor front support. Several of the impeller vanes had large tip crops at the outer leading edge corner.

50 PSI air was applied to the Pc pneumatic line in order to check the pneumatic system for leaks. A soap solution was applied to all fittings and connections and lines. No leakage was detected.

The fuel feed line from the fuel spray nozzle to the turbine heat shield was loosened to inspect for presence of fuel. Approximately 1 tablespoon of fuel drained out of the line while the engine was near vertical, aft end up, in the turnover stand. The fuel appeared clean and clear with no detectable adverse odor. The fuel spray nozzle tip displayed a uniform black soot pattern with no sign of carbon deposits, blockage, or streaking.

Upon acceptance of its condition by the NTSB, the engine was transported to the test stand in a ground transportation cart.

After examination by a Rolls-Royce mechanic, the engine was considered acceptable to run on the production test cell. The engine was installed on test cell #148 and a 6-point performance test was conducted to new engine production standards in accordance with PTS (Production Test Specification) 827 Rev. D.



Engine on Test Stand

The engine successfully started, ran and shut down a total of 3 times. The engine successfully completed ground-idle, flight-idle, max-continuous-power and take-off power runs, in addition to “wave-off” max-power increases. Vibrations were well within limits.

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.

It was noticed prior to the engine test that the max fuel flow stop was set to the low side on the Fuel Control Unit (FCU). This is a field adjustable setting that can be tweaked by mechanics for starting and related operational purposes. This may have been a contributor to the inability of the engine to achieve the max specification horsepower rating but was not considered as contributory to the accident sequence. Test cell technicians stated that it is very common for field return investigation engines to be set or rigged in this same manner.

Corrected for standard atmospheric conditions, the engine was 4.8% below new-production standards at maximum (take-off) power.¹ It was noticed during the engine test however, when checking the functionality of the anti-ice system that the anti-ice solenoid valve was inoperative and was failed in the open position (per design). This was confirmed during the test when the expected 12-15°F rise in MGT was not experienced when the anti-ice valve was switched to the ON position. The valve was also functionally tested after engine shutdown using test stand test power and confirmed to be inoperative. The as-received valve was temporarily replaced with a new anti-ice valve of equivalent standards and performed in accordance with PTS requirements.

Note 1: The performance values achieved during the test were the result of running the engine with the faulty anti-ice valve. The predicted values for this same engine with an operationally good anti-ice valve were an approximate 4.5% gain in power at MGT. This would effectively bring the takeoff power very close to new-production standard.

The testing was terminated following successful completion of the wave-off test and power calibration activities. The engine was removed from the test stand and delivered back to the inspection and preparation area at which point the engine was placed in the turnover stand, redressed with its originally shipped components and placed back into the shipping container.

Engine Maintenance and Records

Manufacturer:	Rolls-Royce Corporation
Engine Model:	M250-C30P
Rating:	650 Shaft Horsepower
Serial Number:	CAE890152

Component	Serial Number	Part Number	TSO	Total Time
Engine	CAE-890152	23004545	492	17261.7
Gearbox	CAG-90118	23053349	5324.7	15300.9
Compressor	CAC-91399	23051643	3769.4	13572.4
Turbine	CAT-97747	23035128	1486.9	14903.8
Fuel Control	337144	23070613	UNKNOWN	UNKNOWN
Governor	HR49007	23086751	392.3	392.3
Fuel Pump	T0567	6896822	149.8	UNKNOWN
Fuel Nozzle	AG72164	23077188	1509	UNKNOWN
Bleed Valve	FF44203	23073353	UNKNOWN	UNKNOWN

Summary of Findings:

There was no evidence of engine fire, failure or malfunction.

The engine performed satisfactorily on the test cell.

All available evidence suggests the engine was capable of producing sufficient power and responding to throttle inputs. While the engine testing demonstrated a shortage in power compared to new production standards, this is not considered to be contributory to the accident sequence.