Australian Government
Australian Transport Safety Bureau

Engine malfunction and forced landing involving Bell 206, VH-ONE

39 km NNE Sydney Airport, New South Wales, 11 June 2017

ATSB Transport Safety Report
Aviation Occurrence Investigation
AO-2017-060
Final – 19 September 2017

Released in accordance with section 25 of the *Transport Safety Investigation Act 2003*

Publishing information

Published by: Australian Transport Safety Bureau
Postal address: PO Box 967, Civic Square ACT 2608
Office: 62 Northbourne Avenue Canberra, Australian Capital Territory 2601
Telephone: 1800 020 616, from overseas +61 2 6257 4150 (24 hours)
Accident and incident notification: 1800 011 034 (24 hours)
Facsimile: 02 6247 3117, from overseas +61 2 6247 3117
Email: atsbinfo@atsb.gov.au
Internet: www.atsb.gov.au

Addendum

Page	Change	Date

Engine malfunction and forced landing involving Bell 206, VH-ONE

What happened

On 11 June 2017, at about 1130 Eastern Standard Time (EST), the pilot of a Bell 206B helicopter, registered VH-ONE, conducted a forced landing about 39 km north-north-east of Sydney Airport, New South Wales. In addition to the pilot, there were four passengers on board.

At about 1107, the helicopter departed Sydney Airport for a planned 45 minute scenic (charter) flight to the north of Sydney. The cloud base was about 1,200 ft over water, but lower over land. Therefore, the pilot elected to conduct the entire flight over water. About 20 minutes after departing, as the helicopter tracked north, the weather deteriorated and the pilot elected to turn south, back towards Sydney (Figure 1).

Figure 1: VH-ONE flight path in red (left) and landing site (right)

Source: Operator, modified by the ATSB

While tracking south at about 1,000 ft, the pilot noticed engine torque fluctuations and a yawing[1] motion, which he described as 'quite alarming'. The pilot identified a sports field out to his right, started a descending right turn towards the field and broadcast a MAYDAY[2] call on the area frequency. Immediately after the radio broadcast, the pilot noticed a significant change in the engine noise, which he described as 'screaming…metallic high pitch noises'.[3] Not knowing what was wrong with the engine, the pilot lowered the collective[4] to maintain main rotor speed and then commenced an autorotation.[5]

---

1 Yawing: the motion of an aircraft about its vertical or normal axis.

2 MAYDAY: an internationally recognised radio call announcing a distress condition where an aircraft or its occupants are being threatened by serious and/or imminent danger and the flight crew require immediate assistance.

3 The pilot was wearing an active noise reduction headset, but the active noise reduction function was selected off.

4 Collective: a primary helicopter flight control that simultaneously affects the pitch of all blades of a lifting rotor. Collective input is the main control for vertical velocity.

5 Autorotation is a condition of descending flight where, following engine failure or deliberate disengagement, the rotor blades are driven solely by aerodynamic forces resulting from rate of descent airflow through the rotor.

After entering the autorotation, the pilot looked down at the instruments and noted that the power turbine revolutions per minute needle was split[6] from the main rotor revolutions per minute needle. However, he could not recall the exact power turbine speed indication. The unusual engine noise continued and the pilot elected to shutdown the engine. At about the same time, the pilot identified another landing site that he was more confident of reaching and turned left towards that site (Figure 1). The pilot completed the autorotation to a zero speed touchdown, which resulted in a hard landing and minor helicopter damage, but no injuries.

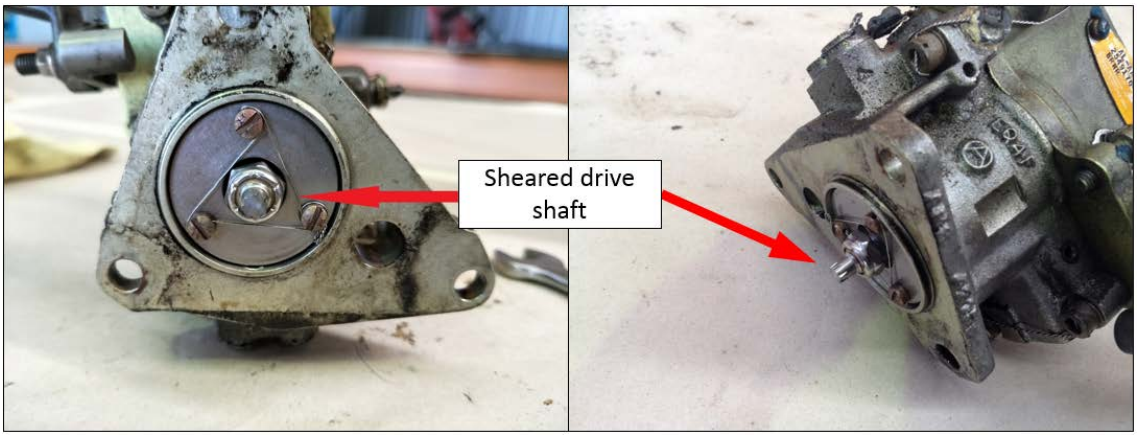
After landing, the pilot checked the warning lights and confirmed there was no fire, pulled the circuit breaker for the warning horns that were operating and made a broadcast that they had landed safely. The pilot then checked on the welfare of the passengers and prevented one passenger from attempting to exit the helicopter with the rotors still turning.[7] The pilot then made another broadcast with the street address of the landing site. Once the rotors stopped turning, the pilot exited the helicopter and assisted the passengers. By this time, emergency services were on the scene as the landing site was close to a fire station.

Maintenance inspection

Following retrieval of the helicopter, it was inspected by the operator's maintenance organisation. They found that the power turbine governor drive shaft had sheared and that the drive shaft did not have freedom of rotation (Figure 2). The governor had a maintenance program life of 2,000 hours (time between overhaul) and at the time of the failure it had completed 794.7 hours. The next inspection due was in 96.5 hours at the next 300 hour engine inspection. The 300 hour inspection was as follows:

> Check the fuel control and power turbine governor linkage for freedom of operation, full travel, and proper rigging. Check the security of linkage for loose or worn linkage and linkage bolts.

Figure 2: Sheared power turbine governor drive shaft



Source: CASA (left) and operator (right), modified by the ATSB

Power turbine governor

The power turbine drives the rotors, so the speed of the power turbine is proportional to rotor speed under normal powered flight conditions. The power turbine also drives the power turbine governor, which incorporates flyweights located on a spool bearing. A change in the drive speed will change the position of the flyweights, which will move the spool bearing in an axial direction. Axial movement of the spool bearing within the governor varies the sensing mechanism of the fuel control unit to adjust fuel flow to the engine, thereby restoring power turbine and rotor speed to the required datum in order to maintain a constant rotor speed.

---

[6] The term used to describe the position of the two needles on the engine/rotor tachometer when the two needles are not superimposed.

[7] The helicopter's rotor brake was inoperable and the pilot commented that they had never operated a 206 in the past equipped with an operable rotor brake. The rotor brake is a device used to stop the rotor blades during shutdown.

To minimise transient droops[8] in rotor speed, the collective is mechanically connected to the governor, so that any change in the collective setting by the pilot will reposition the governor shaft. This will, in turn, also adjust the fuel flow to the engine as the pilot moves the collective in order to maintain a constant power turbine (and rotor) speed as power demands change.[9]

Power turbine governor history

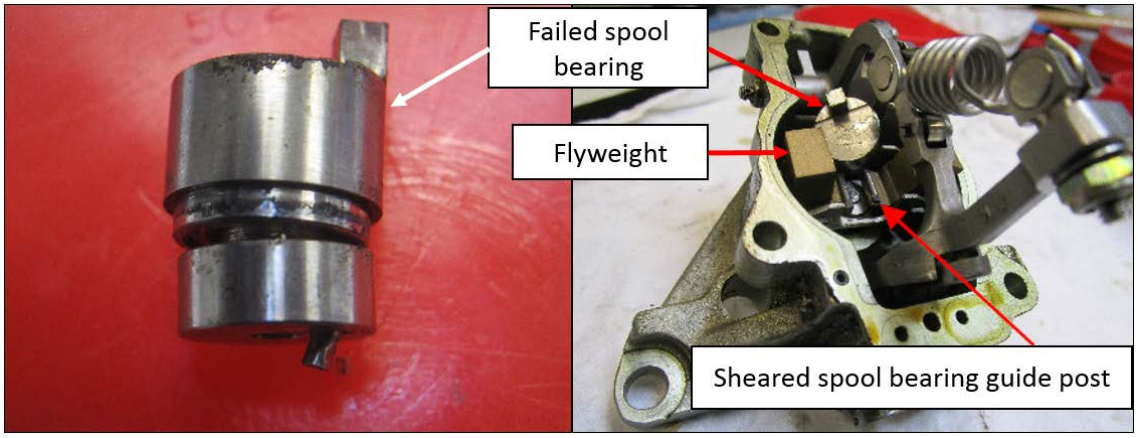
In 2008, Bell (aircraft manufacturer) issued alert service bulletin 206-08-117 on the subject: *Engine, fuel and control – power turbine governor increased reliability*. The purpose of the bulletin was to achieve complete distribution of Rolls-Royce (engine manufacturer) commercial engine bulletin (CEB) 1402. CEB 1402 was a covering document for Honeywell (part manufacturer) service bulletin GT-73-344, which introduced a new bearing assembly (spool bearing) to 'increase the reliability of the power turbine governor'. The requirement was to remove bearing assembly part number 2544198 and install part number 2526146. On completion of CEB 1402 (GT-73-344) the power turbine governor was to be re-identified from Honeywell part number 2549170-1 to Honeywell part number 2549170-2.

The incident governor was received by a third party repair station[10] on 23 November 2015 as power turbine governor part number 2549170-1. The unit was reconditioned and CEB 1402 was complied with. The unit was returned to service as modified part number 2549170-2. It was issued with an authorised release certificate on 14 March 2016, with the work certified by the repair station. The release certificate indicated that the work done on the governor complied with CEB 1402.

Power turbine governor teardown report

Following the removal and external inspection of the incident power turbine governor, the unit was sent to an authorised Rolls-Royce maintenance, repair and overhaul centre. A teardown (disassembly) of the unit was conducted on 21 July 2017. Disassembly of the governor revealed a sheared spool bearing guide post, failed spool bearing and consequential damage to other parts inside the governor (Figure 3).

Figure 3: Spool bearing (left) and power turbine governor (right)



Source: Overhaul organisation (courtesy Rolls-Royce), modified by ATSB

[8] Transient droop or over-swing is the variation in rotor speed that occurs during changes in power initiated by a movement of the collective lever.

[9] Increasing the pitch of the rotor blades increases drag, which demands more power from the engine to maintain rotor speed. Decreasing the pitch of the rotor blades decreases drag, which demands less power from the engine to maintain rotor speed.

[10] The repair station was a United States Federal Aviation Administration and European Aviation Safety Agency certified repair station specialising in the test, repair and overhaul of Rolls-Royce 250 engine accessories. Their capabilities list included compressor bleed valves, power turbine governors, fuel pumps and fuel control units.

On inspection, the spool bearing and drive shaft bearing were found to be parts manufacturer approval (PMA) parts, rather than Honeywell original equipment manufacturer (OEM) parts.[11] The manufacture of PMA parts is based on the manufacturer demonstrating to the authority (United States Federal Aviation Administration) that it has developed specifications that will produce a part equal to the original. However, when the overhaul centre compared the PMA spool and drive bearings installed in the governor with OEM equivalent parts, they found discrepancies between the products (Figure 4). Figure 4 depicts the spool bearings top left, right and bottom left, and the drive shaft bearings bottom right.

Figure 4: Comparison of OEM and PMA bearings

Source: Overhaul organisation (courtesy Rolls-Royce)

Previous occurrences

A search of the ATSB occurrence database and the Civil Aviation Safety Authority defect reporting database was conducted for previous power turbine governor faults with the Bell 206 helicopter.

[11] The spool bearing was identified by the overhaul centre as spool bearing PMA part number 2526146.

The ATSB database search of 'powerplant/propulsion' occurrences with the Bell 206 between the period 2003 and 2017 found nine occurrences of interest. Seven involved an undetermined cause for engine malfunction, one (ATSB investigation AO-2007-013) included the power turbine governor as a possible factor, and one (occurrence reference number 201308817, not investigated by the ATSB) indicated that the power turbine governor shaft splines were found to be worn off:

- In AO-2007-013, the helicopter sustained an engine power loss. The first indication the pilot reported noticing was a slight yaw kick in the helicopter. The power loss resulted in a ditching in the ocean and corrosive damage to the engine and its components. The reason for the power loss was not determined due to the subsequent damage.
- In 201308817, the pilot reported that shortly after take-off the engine started to overspeed and underspeed with torque and rotor speed fluctuations. The pilot immediately landed without further incident.

The Civil Aviation Safety Authority database search found five reports, of which four were related to the power turbine governor drive shaft shearing. In the fifth, the fault with the power turbine governor was not recorded.

Main rotor blade sailing

During start-up and shutdown there is less centrifugal force on the main rotor disc than when it is at operating speed. At these slower rotational speeds, the rotors are more susceptible to the influence of the wind conditions, which can cause large blade flapping movements if the local wind velocity changes during rotation. This condition is known as blade sailing. In this situation the height of the rotor disc will vary to a greater extent than at operational speed, which increases the risk of a blade striking a person or object underneath the rotor disc.

Safety analysis

The pilot elected to conduct a precautionary landing following his observation of uncommanded torque fluctuations. Soon after the torque fluctuations started, the pilot noted unusual engine noises, which concerned him to the point of electing to shut down the engine in-flight and conduct a forced landing. The pilot had already lowered the collective lever to maintain rotor speed before electing to shutdown the engine, which likely contributed to him completing a successful autorotation and landing with no reported injuries and only minor damage to the helicopter.

After landing, the pilot intervened to prevent a passenger exiting the helicopter with the rotors still turning. The pilot's actions prevented a potential serious or fatal injury to the passenger from them being struck by the rotors at a time of increased blade sailing risk.

The post-incident inspection of the helicopter revealed the power turbine governor drive shaft had sheared. Further examination revealed that the governor spool bearing had failed and sheared the spool bearing guide post. This resulted in consequential damage to other parts within the governor and the failure of the drive shaft.

The spool bearing was found to be a PMA part, which was installed in place of an OEM part by a third party repair station when the governor was last overhauled in 2015. While a comparison between the PMA spool bearing and OEM spool bearing revealed discrepancies, it was not determined if these discrepancies contributed to the failure of the spool bearing.

Findings

These findings should not be read as apportioning blame or liability to any particular organisation or individual.

- The power turbine governor spool bearing was found to have failed and sheared the spool bearing guide post. This likely resulted in the failure of the governor drive shaft and engine malfunction.

- In response to the engine malfunction, the pilot shutdown the engine and performed a successful forced landing.
- The pilot's intervention to prevent a passenger exiting the helicopter while the rotors were still turning avoided a potential serious or fatal injury at a time of increased risk of blade sailing.
- The power turbine governor failure occurred within the prescribed time between overhaul periods. On inspection, the failed spool bearing was found to be a parts manufacturer approval part and not an original equipment manufacturer part, however, it was not determined if differences between the parts contributed to the failure of the spool bearing.

Safety message

The pilot commented that maintaining rotor speed was his number one priority. If he had attempted to troubleshoot the problem without entering an autorotation, he could have potentially lost rotor speed and compromised his ability to safely conduct the forced landing.

The United States Federal Aviation Administration Helicopter Flying Handbook stated that having a low rotor speed during an autorotation may result in a less than successful manoeuvre. Specifically, if the speed decayed to the point of a fully developed rotor stall,[12] the result would usually be fatal, especially if it occurred at altitude. This incident highlighted how the precautionary actions taken by the pilot minimised the risk of an unfavourable outcome.

General details

Occurrence details

Date and time:	11 June 2017 – 1130 EST	
Occurrence category:	Serious incident	
Primary occurrence type:	Engine failure or malfunction	
Location:	39 km north-north-east from Sydney Airport, New South Wales	
	Latitude: 33° 38.02' S	Longitude: 151° 19.47' E

Aircraft details

Manufacturer and model:	Bell Helicopter Company 206B	
Registration:	VH-ONE	
Serial number:	1240	
Type of operation:	Charter – passenger	
Persons on board:	Crew – 1	Passengers – 4
Injuries:	Crew – 0	Passengers – 0
Aircraft damage:	Minor	

About the ATSB

The Australian Transport Safety Bureau (ATSB) is an independent Commonwealth Government statutory agency. The ATSB is governed by a Commission and is entirely separate from transport regulators, policy makers and service providers. The ATSB's function is to improve safety and public confidence in the aviation, marine and rail modes of transport through excellence in: independent investigation of transport accidents and other safety occurrences; safety data recording, analysis and research; and fostering safety awareness, knowledge and action.

[12] A stall of the main rotors reduces rotor thrust and increases the rate of descent, which, in turn, will deepen the stall without corrective action from the pilot.

The ATSB is responsible for investigating accidents and other transport safety matters involving civil aviation, marine and rail operations in Australia that fall within Commonwealth jurisdiction, as well as participating in overseas investigations involving Australian registered aircraft and ships. A primary concern is the safety of commercial transport, with particular regard to operations involving the travelling public.

The ATSB performs its functions in accordance with the provisions of the *Transport Safety Investigation Act 2003* and Regulations and, where applicable, relevant international agreements.

The object of a safety investigation is to identify and reduce safety-related risk. ATSB investigations determine and communicate the safety factors related to the transport safety matter being investigated.

It is not a function of the ATSB to apportion blame or determine liability. At the same time, an investigation report must include factual material of sufficient weight to support the analysis and findings. At all times the ATSB endeavours to balance the use of material that could imply adverse comment with the need to properly explain what happened, and why, in a fair and unbiased manner.

About this report

Decisions regarding whether to conduct an investigation, and the scope of an investigation, are based on many factors, including the level of safety benefit likely to be obtained from an investigation. For this occurrence, a limited-scope, fact-gathering investigation was conducted in order to produce a short summary report, and allow for greater industry awareness of potential safety issues and possible safety actions.