CAA OCCURRENCE 21/3316

ROBINSON HELICOPTER COMPANY R44 RAVEN II

ZK-HVX

HEAVY LANDING FOLLOWING TOTAL ENGINE POWER LOSS

WINDWHISTLE CANTERBURY NEW ZEALAND

12 JUNE 2021

Photo: Supplied by the helicopter operator

Foreword

New Zealand's legislative mandate to investigate an accident or incident are prescribed in the Transport Accident Investigation Commission (TAIC) Act 1990 (the TAIC Act) and Civil Aviation Act 1990 (the CA Act).

Following notification of an accident or incident, TAIC may open an inquiry. CAA may also investigate subject to Section 72B(2)(d) of the CA Act which prescribes the following:

> **72B Functions of Authority**
>
> (2) The Authority has the following functions:
>
> > (d) To investigate and review civil aviation accidents and incidents in its capacity as the responsible safety and security authority, subject to the limitations set out in section 14(3) of the Transport Accident Investigation Commission Act 1990

The purpose of a CAA safety investigation is to determine the circumstances and identify contributory factors of an accident or incident with the purpose of minimising or reducing the risk to an acceptable level of a similar occurrence arising in the future. The safety investigation does not seek to ascribe responsibility to any person but to establish the contributory factors of the accident or incident based on the balance of probability.

A CAA safety investigation seeks to provide the Director of Civil Aviation with the information required to assess which, if any, risk-based regulatory intervention tools may be required to attain CAA safety objectives.

The CAA acknowledges the cooperation and assistance provided by the Federal Aviation Administration (FAA), RHC and the helicopter operator during the safety investigation.

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Glossary of abbreviations:

AGL	above ground level
AMSL	above mean sea level
CAA	Civil Aviation Authority
E	east
ft	foot or feet
FPRV	fuel pressure relief valve
km	kilometre(s)
m	metre(s)
NZST	New Zealand Standard Time
PSI	Pounds per square inch
RPM	revolutions per minute
S	south
UTC	Universal Time Coordinated
VDC	Volts direct current
VHF	very high frequency

Data summary

Aircraft type, serial number and registration:	Robinson Helicopter Company R44 Raven II, s/n 11112 ZK-HVX
Number and type of engines:	1 x Lycoming IO-540-AE1A5
Year of manufacture:	2006
Date and time of accident:	12 June 2021, 1505 hours[1] (approximately)
Location:	Windwhistle, Canterbury, New Zealand Latitude[2]: S 43° 28' 39.1" Longitude: E 171° 38' 35.1"
Type of flight:	Commercial air transport
Persons on board:	Crew: 1 PAX: 3
Injuries:	Crew: 1 serious PAX: 3 serious
Nature of damage:	Aircraft destroyed
Pilot-in-command's licence	New Zealand Commercial Pilot Licence (H)
Pilot-in-command's total flying experience:	2267 hours total 417 on type 42 last 90 days
Investigator in Charge:	Mr C P Grounsell

[1] All times in this report are NZST (UTC + 12 hours) unless otherwise specified

[2] WGS-84 co-ordinates

Executive summary

On Saturday 12 June 2021, at 1515 hours, the Civil Aviation Authority (CAA) was notified that a helicopter identified as ZK-HVX (HVX), a Robinson Helicopter Company (RHC) R44 Raven II, had crashed on the golf course at the Fable Terrace Downs High Country Resort, approximately 39 nautical miles west of Christchurch New Zealand. The pilot and three passengers survived the accident but suffered serious injuries. The Transport Accident Investigation Commission (TAIC) was notified but chose not to open an inquiry. A CAA field investigation was commenced the following day.

The purpose of the flight was to transport a bride and groom along with a photographer, following a wedding ceremony held at the Fable Terrace Downs High Country Resort, to a suitable location for wedding photography. The helicopter was observed by several witnesses to lift off and depart, climbing to the north of the resort. Approximately thirty seconds after departure, the sound being emitted from the helicopter suddenly reduced and it was then seen to descend and land heavily on the golf course.

During the CAA investigation, it was found that the fuel pressure relief valve (FPRV) and the auxiliary fuel boost pump were not meeting manufacturers specifications, with the FPRV also possibly sticking in the open position, affecting fuel flow to the engine. It was initially thought that a combined failure of both components may have resulted in a total engine power loss, though testing by RHC did not replicate this. However, based on test figures provided by RHC, there was little margin of fuel flow available if the FPRV had stuck open, combined with an auxiliary fuel pump failure, to ensure continued engine operation.

Information from industry in New Zealand indicted that several FPRVs were also found to be operating below the required pressure specifications. Considering this, the CAA issued Continuing Airworthiness Notice (CAN) 73-006 *Robinson R44 II helicopters – Fuel System Pressure Relief Valve (PRV)* on 18 August 2021. The CAN recommended that operators and maintainers of R44 II helicopters carry out the RHC check of the FPRV as detailed in the RHC R44 II Maintenance Manual.

The FPRV and auxiliary fuel boost pump were not previously classified by RHC as lifed items. Following the accident, RHC added these items to the list of components to be changed at the 2200 hour/12-year airframe overhaul.

CAN 73-006 *Robinson R44 II helicopters – Fuel System Electric Fuel Pump and Pressure Relief Valve (PRV)* was further revised in February 2022 and December 2023. The latest revision advises operators to replace the auxiliary fuel boost pump and FPRV at the manufacturers recommended replacement interval. The revision to the CAN was deemed necessary as the CAA had been made aware of several R44 II helicopters which were still operating with components which exceeded the RHC component life requirements.

1. Factual information

1.1 History of the flight

1.1.1 On the day of the accident, after completing the flight planning and pre-flight checks, the pilot departed in HVX from the operator's home base at approximately 1420 hours. The pilot then flew to the Fable Terrace Downs High Country Resort, landing at approximately 1440 hours.

1.1.2 The approach and landing by HVX at the resort was captured on video by one of the wedding guests. The video was unremarkable and showed that HVX appeared to be operating normally.

1.1.3 Following a short waiting period, the pilot and the three passengers boarded the helicopter. The pilot then started the engine.

1.1.4 The photographer realised that they would require a jacket for the photo shoot and a person was despatched to get this for them. During this waiting time, which amounted to 17 minutes, the pilot kept the engine running at approximately 70 percent engine RPM. During this time the photographer took some photos from within the cabin, which captured the instrument panel.

1.1.5 Due to the time taken to locate the jacket, the photographer decided to leave without it. The pilot then increased power and took off, starting a climb towards the north of the resort.

1.1.6 The wedding guest recorded another video of the lift-off and initial departure of HVX. The 20-second video recording revealed nothing out of the ordinary with the helicopter or its operation. It's estimated the video recording finished 10 seconds before the engine power loss occurred.

1.1.7 Once airborne, the photographer took another series of photos as the helicopter gained altitude. The final photo taken was approximately five seconds before the total engine power loss. Most of the instrument panel was captured in this photo.

1.1.8 The pilot reported that they were climbing out at 60 knots when they heard a 'pop' like sound followed immediately by a total loss of engine power. The pilot initiated an emergency autorotation and turned HVX approximately 45 degrees to the left, aiming towards a clear area on one of the golf course fairways.

1.1.9 Witnesses on the golf course observed the helicopter descend, and later reported that it appeared to be rocking from side to side as it approached the fairway.

1.1.10 As HVX descended, it struck a small tree on the edge of the fairway, and in doing so broke off several small branches. HVX then struck the ground upright with significant energy. The landing gear collapsed due to the high rate of descent.

1.1.11 During the initial ground contact, the main rotor blades severed the tail boom which came to rest 31 metres from the fuselage. HVX then slid across the ground for five metres and rotated approximately 90 degrees to the left before coming to rest.

1.1.12 First responders provided aid to the occupants until emergency services arrived. All occupants appeared to be suffering from severe back injuries.

1.1.13 The helicopter was then taken to a location where further investigation was carried out.

1.1.14 The accident occurred in daylight, at approximately 1505 hours NZST, approximately 39 nautical miles west of Christchurch New Zealand, at an elevation of 1548 feet amsl, latitude S 43° 28' 39.1", longitude E 171° 38' 35.1".

1.2 Injuries to persons

Injuries	*Crew*	*Passengers*	*Other*
Fatal	0	0	0
Serious	1	3	0
Minor/None	0	0	

Table 1: Injuries to persons

1.3 Damage to aircraft

1.3.1 The helicopter was subjected to high vertical deceleration forces when it struck the ground, which resulted in significant deformation of the aft fuselage and the cabin roof. The landing gear collapsed, and the tail boom was severed by the main rotor blades. The tail rotor blades were damaged with one blade fractured, probably from contact with the ground. This was most likely due to the high-nose attitude of the helicopter, as the pilot attempted to arrest the rate of descent before landing.

1.4 Other damage

1.4.1 Nil.

1.5 Personnel information

Flying hours	All types	On Type
Last 24 hours	0.4	0.4
Last 7 days	6.5	1.8
Last 30 days	7.7	5.1
Last 90 days	42.0	34.7
Total hours	Approximately 2267	Approximately 417

Table 2. Pilot flight hours

1.5.1 The pilot, aged 53 years, was issued with a CPL(H) on 19 December 2007 and holds a B-category instructor rating which was issued on 01 August 2012. At the time of the accident, the pilot was current in instructing on the Robinson R44 helicopter.

1.5.2 The pilot had completed their annual flight instructor renewal and flight crew competency check during December 2020, which were carried out in HVX. During January 2021, the pilot completed the annual Robinson Helicopter safety awareness refresher training.

1.5.3 At the time of the accident the pilot held a Class 1 medical certificate, valid until 20 September 2021, which was appropriate for single-pilot air operations carrying passengers.

1.6 Aircraft information

1.6.1 Robinson Helicopter Company R44 Raven II, serial number 11112, was manufactured in the USA in February 2006 and exported to New Zealand. The helicopter was initially registered as ZK-IEG and issued a standard category airworthiness certificate by the Civil Aviation Authority of New Zealand. The helicopter was re-registered as ZK-HVX in January 2011.

1.6.2 In June 2017 HVX had undergone an overhaul for the required 2200 hour/12-year inspection, in accordance with the RHC R44 Maintenance Manual.

1.6.3 The Lycoming IO-540-AEIA5 engine s/n RL-22938-48E was a zero-timed factory rebuilt engine installed in HVX during the 2200 hour/12-year inspection. At the time of the accident, the engine had accrued 823.5 hours since rebuild.

1.6.4 Before the accident, the last recorded maintenance carried out on HVX was a 50-hour Lycoming engine inspection, completed in May 2021. At this time HVX had accrued 3005.3 hours, as recorded in the helicopter logbooks. During this inspection, the engine-driven fuel pump (part number AF15473) was found to be leaking from the drain, and it was replaced. No further maintenance was recorded as having been performed. At the time of the accident, HVX had accrued 3023.5 hours total time.

1.6.5 It was determined by calculation that, at the time of the accident, the all-up weight was 2354 pounds (lbs), which is within the maximum allowable all-up take-off weight of 2500 lbs. The centre of gravity was within the limits stipulated in the R44 II flight manual.

1.7 Meteorological information

1.7.1 From analysis of the weather conditions observed in the recorded video and photographs at the time of the accident, the weather conditions were determined to be:

- Wind direction: approximately 340°M
- Wind strength: 5-10 knots
- Cloud: No significant cloud
- Visibility: Unlimited.

1.7.2 Low-level wind shear or localised downdraughts may have existed as a result of a stand of tall trees located upwind of the helicopter's flight path. Refer Figure 1, page 11.

1.8 Aids to navigation

1.8.1 Not applicable.

1.9 Communications

1.9.1 Although HVX was fitted with VHF radios, due to the location where the helicopter was operating, there were no ground stations in the vicinity to enable the recording of any radio transmissions from HVX.

1.10 Aerodrome information

1.10.1 Not applicable.

1.11 Flight recorders

1.11.1 HVX was fitted with a TracPlus™ flight tracking system which transmitted flight data to the operator's computer at 15-second intervals. Due to the short duration of the flight, the system transmitted only two sets of data while HVX was airborne before the accident.

1.11.2 With reference to Figure 1, TracPlus™ data at point 'B' the altitude was approximately 45 feet above ground level (AGL), groundspeed 37 knots and heading 008°True. At point 'C' the altitude was approximately 160 feet AGL, 40 knots groundspeed and heading 322°True. Point 'D' is the location of the accident site.

1.11.3 Figure 1 also incorporates the final photo taken by the photographer, and the position relative to the flight track where that photo was taken.

1.11.4 For clarity, the instrument indications which can be observed in the photo are:

Altitude	1700 feet amsl (150 feet AGL)
Airspeed	50 knots
Rate of climb	450 feet per minute
Engine RPM	102%
Rotor RPM	102%
Manifold Pressure	24 InHg

Figure 1: ZK-HVX accident flight path (Google Earth). Inset photo taken by the photographer

1.12 Wreckage and impact information

1.12.1 The accident occurred on the golf course located at the Fable Terrace Downs High Country Resort, approximately 39 nautical miles west of Christchurch, New Zealand.

1.12.2 During the accident sequence, the aft tail boom initially struck the ground, followed by the landing gear, which then collapsed. The tail boom was severed by the main rotor. HVX then slid for five metres before coming to rest upright. Refer Figure 2.

Figure 2: Ground scars (CAA photo)

1.12.3 The main rotor blades were intact, although they exhibited signs of damage from contact with the tail boom, and they had minor deformation which corresponded to the vertical deceleration during the ground impact. One pitch link had failed at the upper end, likely due to overload when the main rotor blade struck the tail boom.

1.12.4 The aft tail boom with the tail rotor attached was located 31 metres from the helicopter. Damage observed on the left side of the tail boom clearly indicates that it had been struck by the main rotor. Refer Figure 3. Witness marks observed on the tail rotor blades and sections of tail rotor drive shaft indicated that the tail rotor was being driven by the transmission when the tail rotor struck the ground.

Figure 3: Tail boom (CAA photo)

1.12.5 The fuselage showed corresponding deformation from the ground impact. The Perspex® windscreens had shattered. The aluminium structure supporting the bladder fuel tanks showed deformation, although fuel leakage had not occurred. Fire and Emergency personnel had cut away sections of the door frames to enable extraction of the occupants. Refer Figure 4.

Figure 4: HVX Fuselage indicating damage (CAA photo)

1.12.6 Initial inspection of HVX determined that the engine was not rotating at the time of ground impact. This was shown by witness marks on the alternator drive pulley from contact with the starter ring gear.

1.12.7 Both fuel tanks were intact and visual inspection of the fuel level indicated the tanks were approximately half-full. A fuel sample was taken from the fuel drain points, the fuel sampled was determined to be avgas and no contamination was evident.

1.13 Medical and pathological information

1.13.1 The pilot was reported to be in good health and adequately rested before the flight. They had begun duty at 1300 hours on the afternoon of the accident and had had the previous two days off work. Fatigue was considered not to be a factor in the accident.

1.13.2 Testing for the presence of alcohol and drugs was not conducted by the CAA as there is no current legislation to provide for this testing.

1.14 Fire

1.14.1 Fire did not occur.

1.15 Survival aspects

1.15.1 The combined lap and shoulder harnesses worn by the pilot and passengers restrained them in their seats during the accident sequence.

1.15.2 All four persons on board received serious back injuries when the helicopter struck the ground. The seat bases were found to be deformed, and the lower supporting structure had partially collapsed, as it's designed to do in an accident where high vertical down forces are involved.

1.15.3 Although the supporting structure for both fuel tanks had been compromised, the bladder type fuel cells within the structure provided integrity and prevented any fuel leakage, significantly reducing the chance of a fuel-fed fire.

1.16 Tests and research

1.16.1 The day after the accident, the following aircraft systems were initially inspected and checked under CAA supervision:

- The engine ignition system
  - The wiring continuity between the magneto switch and the magnetos was checked. The correct operation of the magneto switch was confirmed for all switch positions. The switch was then disassembled and inspected for signs of arcing across the switch segments. No defects were found.
  - The spark plugs were removed and inspected – the electrodes were all of an appropriate colour with no obvious defects. The magneto timing was checked and found to be correct.
  - A Champion Aerospace LLC SlickSTART™ SS1002 unit was fitted to HVX and connected to both magnetos to aid engine starting. This unit was removed and sent to a local university where it was subjected to testing in accordance with the Champion Aerospace LLC SlickSTART™ operational verification test procedure. The unit performed to the required specifications.
- The core engine
  - The engine was rotated by hand and compression was confirmed in all six cylinders. The rocker covers were removed – correct operation of the valve train was observed.
  - The engine oil filter was removed from the engine, cut open and the filter element inspected. It was found to be unremarkable. The engine oil quantity as measured on the oil dipstick was found to be within limits.
- The engine fuel system
  - The engine was fitted with an Avstar fuel injection servo model RSA-10AD1, which was removed from the engine and sent to a maintenance provider for inspection and testing. No defects were found. The unit was then reassembled and tested on a flow bench in

accordance with the Avstar calibration test specification. It was found that the unit was slightly lean at the maximum test setting, but this is considered not to have affected engine operation during flight.

  - The engine-driven fuel pump was disassembled and inspected with no defects found. The maintenance provider was unable to bench test the pump, however it was later reassembled, refitted to the engine, tested, and found to be serviceable.

- The airframe fuel system

  - A fuel flow check of the airframe fuel system was carried out in accordance with the Robinson R44 Maintenance Manual. The result was within the required specification for the allowable fuel flow rate. The fuel tank and vent lines were also checked for contamination or blockages, of which none were found.

1.16.2 The engine was then removed from the helicopter and sent to a maintenance provider for further investigation under CAA supervision. The engine was installed in a test rig and fitted with a test propeller. The fuel injection servo earlier removed for testing was refitted to the engine. The magnetos removed from the engine were checked on a test bench, found serviceable and refitted to the engine.

1.16.3 The engine was subjected to several test runs, including a high-power run, where it performed to specification. No engine defects were found which could have resulted in the engine power loss in flight.

1.16.4 The FPRV, RHC part number D321-1 was removed for testing by the CAA. It was found that the FPRV was bypassing fuel at a lower pressure than the required specification.

1.16.5 Prior to February 2006, the FPRV relief pressure was set to 28+/-3 psi by the valve manufacturer. From February 2006 onwards, the relief pressure was set to 31+/-1 psi by RHC. HVX was manufactured in February 2006 and fitted with a FPRV with the lower relief pressure setting.

1.16.6 CAA testing of the FPRV installed on HVX determined that the valve began to bypass fuel at 5 psi at a minimal rate, to a maximum flow of 40 USG/hr at 28 psi. The valve was then disassembled for inspection, wear marks were found in the bore of the valve and on the valve shuttle. Small flecks of brown particles were also found in the bore of the valve. These particles were too small for analysis, however, RHC determined that the brown particles were most likely to be fuel gum or residue.

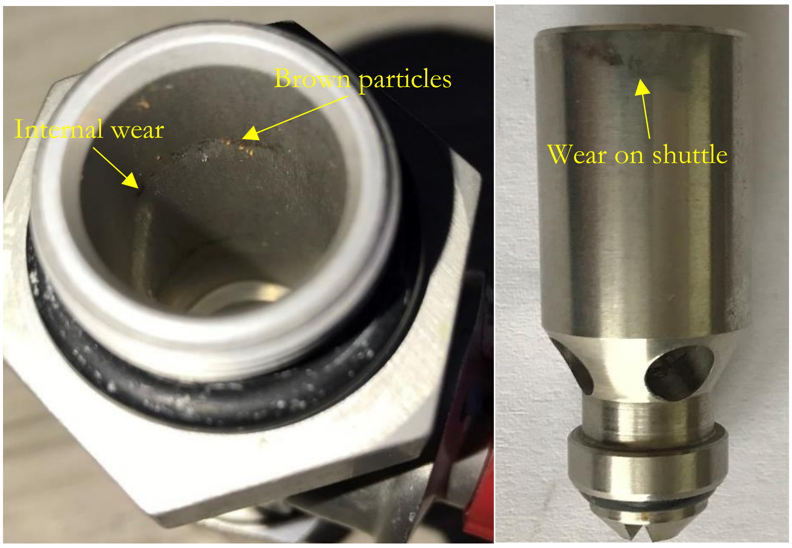

Figure 5: FPRV valve internal wear and suspect particles with FPRV shuttle shown alongside (CAA photo)

1.16.7 The auxiliary fuel boost pump (RHC part number D743-1) was also removed for testing by the CAA. Bench testing of the pump determined the pump output to be 23 USG/hr at 28 psi. According to RHC, the specification for the D743 pump output is 25 USG/hr minimum at 35 psi, when operated at 28 Volts DC.

1.16.8 The boost pump motor was disassembled for inspection. It was found that the motor brushes were worn to the point where one brush fell away from the copper ‘pigtail’ wire and the other brush was also extensively worn. It was also found that the motor bearing closest to the pump was seized, and the bearing outer race was rotating in the motor housing. These defects would have contributed to the low pump output during testing. In October 2021 the CAA advised RHC of both issues involving the FPRV and auxiliary fuel boost pump.

1.16.9 Due to the defects found with both the FPRV and the auxiliary fuel boost pump, it was considered possible that the FPRV may have stuck open following the extended time (17 minutes) that ZK-HVX’s engine was running prior to take-off, due to heating of the valve within the engine compartment. It was considered that a combined failure of the auxiliary fuel boost pump with a stuck open FPRV, may have caused the total engine power loss.

1.16.10 To test the above theory and the effect that a leaking or sticking FPRV may have on engine operation, the FPRV and auxiliary fuel boost pump fitted to HVX were sent to the FAA for testing by RHC. RHC established on another R44II fitted with test equipment, that the maximum bypass fuel flow that could be expected through the FPRV during helicopter operation was approximately 30.9 USG/hr. This was established with the engine at low RPM and the auxiliary fuel boost pump operating.

1.16.11 To simulate the effect a stuck open FPRV may have on engine operation, an adjustable vernier valve set to bypass 30.9 USG/hr was installed in place of the FPRV. A series of test runs were carried out, including high (take-off) power with the circuit breaker for the auxiliary fuel boost pump pulled, deactivating the pump. There was no noticeable change in engine performance.

1.16.12 To determine how much fuel could be bypassed at take-off power before engine operation was affected, the fuel bypass was slowly increased from a starting bypass figure of 22.1 USG/hr. This starting figure was the fuel bypass measured during testing with the engine at take-off power and the auxiliary fuel boost pump inoperative.

1.16.13 The engine began to show signs of rough running with the manifold pressure beginning to increase at approximately 11 USG/hr above the starting figure. The bypass was further increased until the engine was on the verge of shutting down at approximately 14.2 USG/hr above the starting figure.

1.17 Organisational and management information

1.17.1 Nil

1.18 Additional information

1.18.1 Nil

1.19 Useful or effective investigation techniques

1.19.1 Nil.

2. Analysis

2.1 The accident occurred as a result of a hard landing following an emergency autorotation when a total engine power loss occurred after take-off. At the time of the engine power loss, the helicopter was approximately 160 feet above ground level with a forward airspeed of approximately 50 knots.

2.2 All instrument panel indications that could be seen in the photos taken by the photographer in the helicopter during the time waiting on the ground, and in flight, revealed no abnormalities.

2.3 It was apparent the pilot had no warning of the impending total engine power loss, which occurred suddenly, preceded by what they describe as a 'pop' sound. In discussion with a Lycoming representative, it was suggested that the pilot's observations could be indicative of a lean cut, i.e. insufficient fuel for continued engine operation.

2.4 During the CAA investigation, consideration was given as to whether an inadvertent operation of any controls or switches within the cockpit, by either the pilot or front seat passenger, may have affected the operation of the engine. The investigation determined that this was highly unlikely to have occurred.

2.5 Following the loss of engine power, the pilot initiated an emergency autorotation and turned the helicopter approximately 45 degrees to the left towards clear ground. In doing so, the helicopter had turned approximately 90 degrees out of wind. The terrain ahead of the pilot's intended flight path was undulating and scrub-covered, therefore less suitable for landing than the golf course.

2.6 Despite having to turn out of wind to avoid ground obstacles after the engine failed, sufficient rotor RPM was retained to enable the pilot to flare HVX with a nose high attitude at the moment of ground contact.

2.7 At the time that the engine power was lost, HVX was approximately 160 feet AGL with an approximate forward airspeed of 50-55 knots. With reference to the R44 II Height-velocity diagram[3], HVX was operating close to the edge of the 'avoid operation area' on the diagram. Refer Figure 5 below.

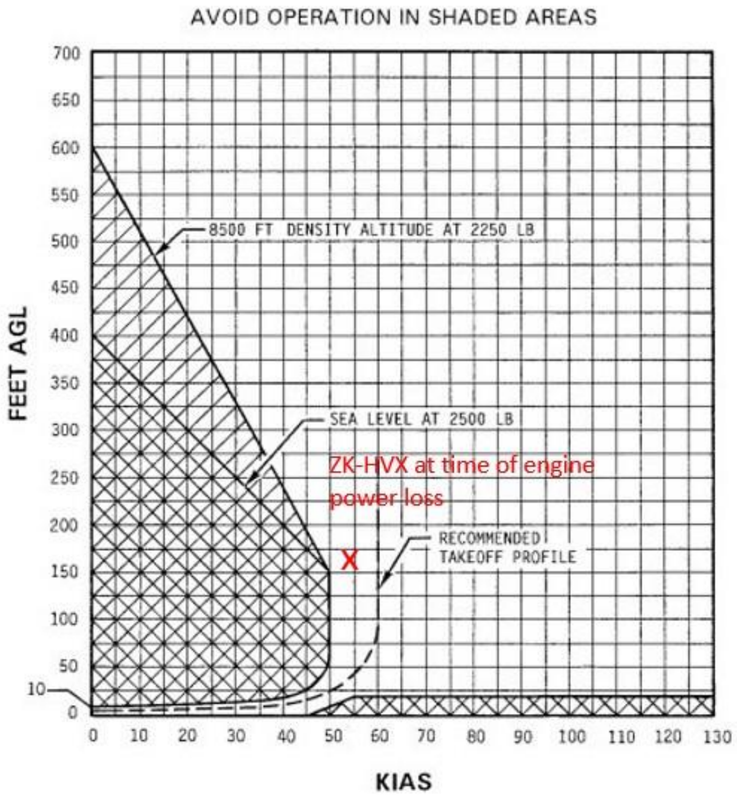

Figure 6: R44 II Height-velocity diagram

2.8 Given the ground obstacles, and the height and speed of HVX when the engine power loss occurred, the pilot would have been presented with a very challenging situation to be able to complete a successful landing, even with an immediate entry into the emergency autorotation.

2.9 It is also possible that the stand of tall trees upwind of the flight path created a wind shear effect or a localised downdraught. This could have affected the final stages of the emergency autorotation as HVX descended and rotor RPM reduced, with the pilot being unable to arrest the rate of descent before striking the ground.

[3] The diagram indicates the combinations of height above ground and airspeed that should be avoided due to safety concerns relating to emergency landings. It is dangerous to operate within the hatched regions of the diagram as it may be impossible for the pilot to complete an emergency autorotation without causing damage to the aircraft, from a starting point within these regions.

2.10 During the CAA investigation, systems and components which may have contributed to the engine power loss were inspected or tested. It was suspected that a leaking or stuck open FPRV, combined with a failure of the auxiliary fuel boost pump, had resulted in an over-lean fuel flow to the engine, causing the total engine power loss. However, testing by RHC, under the supervision of the FAA, failed to result in a total engine power loss with the simulated parameters which likely existed on the accident flight. Only when the fuel bypass was increased to 14.2 USG/hr above the condition that may have existed in HVX, if the FPRV had been stuck in its theoretical maximum bypass condition, did the engine show signs of shutting down.

2.11 The testing carried out by RHC determined that with a total fuel bypass flow of 36.3 USG/hr (22.1 + 14.2), the engine was on the verge of shutting down. At take-off power, the engine fuel consumption is approximately 17 USG/hr, combined with the fuel bypass of 36.3 USG/hr, this equates to a total fuel flow of approximately 53.3 USG/hr. The rated output of the engine driven fuel pump is approximately 45 USG/hr, therefore continued operation of the engine would seem unlikely based on the above figures.

2.12 With a starting fuel bypass flow rate of 22.1 USG/hr and the engine fuel consumption of approximately 17 USG/hr during climb-out, the total fuel flow required equates to approximately 39.1 USG/hr. This is 5.9 USG/hr below the rated flow capacity of the engine driven fuel pump if the auxiliary fuel pump was inoperative. In addition, RHC test data shows that in this condition, the fuel pressure fell to approximately 13.8 PSI. The fuel pressure supply operating limits for the engine fuel servo are 18 to 45 PSI. If the auxiliary fuel boost pump failed in flight, with the FPRV stuck in its maximum bypass position, there would be a very rapid reduction in fuel pressure to the fuel servo from 18.9 PSI to 13.8 PSI which could possibly affect engine operation.

2.13 Following the testing RHC concluded that;
'It was found that a pressure relief valve that was fixed in the most open position achievable in normal operation had no effect on engine fuel flow even at maximum take-off power and even with a simulated failure of the auxiliary fuel pump. Further investigation showed that the valve would need to stick open in a position that allowed an additional 14.2 GPH of bypass fuel flow from the normal "full open" position in order to potentially cause engine stoppage. At this level of bypass fuel flow, even a properly operating auxiliary fuel pump is unable to maintain system pressure and the auxiliary fuel pump light illuminates at all power settings. Therefore, for a valve stuck in a position far enough open to jeopardise engine operation, the pilot should receive a fuel pump warning during idle and runup prior to liftoff'.

2.14 As mentioned in the paragraph above, the R44 II is fitted with an auxiliary fuel pump light, the function of which is to advise the pilot of an auxiliary fuel pump failure during helicopter operation. The light will illuminate, via a pressure switch, when the fuel system pressure falls below approximately 23 PSI, thereby alerting the pilot to a possible failure of the auxiliary fuel boost pump. It could be seen in the photo taken just prior to the engine failure that the auxiliary fuel pump light appeared not to be illuminated, even though the FPRV is suspected to have been stuck open reducing the fuel system pressure (noted during the RHC testing) to 18.9 PSI. Due to damage to the fuel pressure switch sustained during the accident, when bench tested, the switch was found to be operating at 32 PSI and leaking fluid. Therefore, correct operation of the pressure switch fitted to HVX could not be confirmed.

2.15 The auxiliary fuel boost pump, D743-1, fitted to the aircraft was determined to be the original pump fitted when HVX was manufactured. Examination of HVX's logbooks showed the pump had been removed for repair on several occasions, most likely due to worn motor brushes. RHC now specifies upgraded pump part number D743-3 for use on the R44 II, to increase pump reliability.

2.16 Following the identification of the FPRV which was not performing to specification, and information provided by industry in New Zealand of other similar valves, the CAA published Continuing Airworthiness Notice (CAN) 73-006 *Robinson R44 II helicopters – Fuel System Pressure Relief Valve (PRV)* on 18 August 2021. Refer Appendix 1. The CAN recommends that operators and maintainers of R44 II helicopters carry out the RHC check of the FPRV, as detailed in the RHC R44 II Maintenance Manual.

2.17 Subsequently in December 2021, after the CAA had notified RHC of the issues found with the FPRV and auxiliary fuel boost pump, RHC amended the list of components to be replaced during the 2200 hour/12-year airframe overhaul. Added to the list of the components were the auxiliary fuel boost pump and the FPRV. Prior to this, the auxiliary fuel boost pump and FPRV were on condition items with no finite life.

2.18 Following amendment to the component replacement parts list by RHC, the CAA issued revised CAN 73-006 *Robinson R44 II helicopters – Fuel System Electric Fuel Pump and Pressure Relief Valve (PRV)* on 22 February 2022. The revised CAN informed operators and maintainers that RHC had revised the maintenance component requirements in Chapter 1.102 of the R44 series Maintenance Manual.

2.19 Later during 2023, the CAA became aware that several R44 II helicopters continued to operate with PRVs and electric fuel pumps which had exceeded the manufacturers recommend time in service. The CAA could not entirely rule out the possibility that a combined failure of both components may cause a total engine power loss, or result in a loss of engine performance. For that reason, the CAN was again revised (revision 2) on 06 December 2023, recommending that operators and maintainers replace these components at the manufacturers recommended replacement interval. Refer Appendix 1.

3. Conclusions

3.1 The accident occurred following an emergency autorotation when a total engine power loss occurred after take-off, at low level, during climb-out.

3.2 Although the pilot was operating outside of the 'avoid operation area' as depicted on the R44 II height and velocity diagram, they were required to turn out of wind and then avoid ground obstacles.

3.3 Even though the pilot took the immediate actions to enter the emergency autorotation, a successful emergency autorotation could not be assured.

3.4 The heavy landing occurred due to a reduction of rotor energy during the final stages of the emergency autorotation.

3.5 Wind shear or downdraught conditions close to the ground may have affected the final stages of the autorotation.

3.6 HVX had a valid airworthiness certificate and had been maintained in accordance with the relevant maintenance requirements.

3.7 The weight and balance for HVX were within the required limitations.

3.8 Both the FPRV and auxiliary fuel boost pump were the original items fitted to HVX during manufacture and had accumulated approximately 3023 hours in service.

3.9 The auxiliary fuel boost pump fitted to HVX was discovered to be in extremely poor mechanical condition, which may have caused it to stop operating in flight.

3.10 The FPRV was found to be not meeting the manufacturers specification, allowing fuel to bypass at a lower pressure than required by specifications.

3.11 The FPRV was found to be worn internally with small brown particles, possibly fuel gum in the internal bore of the valve. These particles and/or the internal wear in the valve, may have caused the valve to fail open in the maximum bypass flow position.

3.12 The CAA investigation considered it possible that the engine may have failed due to fuel starvation as a result of a combined failure of both the FPRV and auxiliary fuel boost pump. However, this could not be confirmed during the testing carried out by RHC.

4. Safety actions

4.1 In response to finding multiple FPRVs not performing to the manufacturers specifications, the CAA issued CAN 73-006 Robinson R44 II helicopters – *Fuel System Pressure Relief Valve (PRV)* on 18 August 2021. The purpose of the CAN was to request that operators and maintainers carry out the RHC check of the FPRV installed on their R44 II helicopter at the operator’s earliest maintenance convenience.

4.2 The CAN was amended on 22 February 2022 to reflect the changes made by RHC to the list of components to be replaced during the 2200 hour/12-year airframe overhaul to include the FPRV and auxiliary fuel boost pump. The revision recommends that R44 operators assess their aircraft records, and ensure they meet the maintenance requirements in the revised RHC R44 Maintenance Manual.

4.3 On 06 December 2023, a second revision to the CAN was made. The CAA had become aware that were several R44 II helicopters in service with auxiliary fuel boost pumps and FPRVs, which had exceeded the manufacturers recommended replacement time interval. The revised CAN advises that a failure of the PRV is not considered likely to cause an engine failure. However, it appears that a combination of a failed FPRV and auxiliary fuel boost pump could result in a loss of engine performance. For that reason, the CAA recommends that operators and maintainers replace these components at the manufacturers recommended replacement time interval.

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Appendix 1

Continuing Airworthiness Notice 73-006 Revision 2

Robinson R44 II helicopters - Fuel System Electric Fuel Pump and Pressure Relief Valve (PRV)

6 December 2023

Issued by the Civil Aviation Authority of New Zealand in the interests of aviation safety. A Continuing Airworthiness Notice (CAN) is intended to alert, educate, and make recommendations to the aviation community. A CAN contains information and guidance about an airworthiness concern that does not meet the criteria for an Airworthiness Directive (AD). The inspections and practices described in this CAN must still be carried out in accordance with the applicable NZCAR Parts 21, 43 and 91.
CAN numbering is by ATA Chapter followed by a sequential number for the next CAN in that ATA Chapter.

Applicability:

Robinson R44 II helicopters fitted with a Lycoming IO-540 engine.

Purpose:

This revision 2 Continuing Airworthiness Notice (CAN) clarifies the component maintenance requirements for R44 helicopters, adds a recommendation to replace components which have reached the manufacturers recommended replacement interval, and informs aircraft operators and maintainers that Robinson Helicopters Corporation (RHC) have revised the component maintenance requirements specified in the RHC R44 Maintenance Manual.

Refer to Section 1.102 *Additional Component Maintenance* in the RHC R44 Maintenance Manual dated September 2023, or later approved revision.

The RHC R44 Maintenance Manual is available on the RHC website at: https://robinsonheli.com/r44-maint-manual/

The revised component maintenance requirements:

- Electric Fuel Pump P/N D743-1, -2, -3 and -4 must be replaced with a new P/N D743-3 pump at 2200 hours TTIS.
- Fuel Pressure Relief Valve P/N D321-1 must be replaced with a new or overhauled part at 12 years, or before 2200 hours TTIS.

Background:

CAN 73-006 was originally issued in August 2021 to highlight a CAA finding with the Fuel Pressure Relief Valve (PRV) fitted on a Robinson R44 II involved in an accident on 12 June 2021.

The PRV on that aircraft was found to be bypassing an excessive amount of fuel at a much lower pressure than specified.

The CAA is aware of another Robinson R44 II helicopter which the pilot could not start. The PRV on this aircraft was also found bypassing an excessive amount of fuel due to an internal leak.

RHC provide a method for checking the PRV in situation for leaks. Refer to Section 12-83 *Pressure Relief Valve Leakage Check* on page 12.33 in the RHC R44 Maintenance Manual.

Note: This check is not included as a scheduled maintenance activity in the RHC R44 Maintenance Schedule.

The failure of the PRV is not considered likely to cause an engine failure. It appears that a combination of a failed PRV and a failed electric fuel pump could result in a loss of engine performance.

For that reason, CAA are advising operators and maintainers to replace these components at the manufacturers recommended replacement interval.

Recommendation:

CAA recommend that R44 operators assess their aircraft records and ensure that they meet the maintenance requirements in the latest revision RHC R44 Maintenance Manual.

Components which have reached / exceeded the manufacturer's recommended replacement interval should be replaced as soon as possible.

The CAA would like to know if operators have any problems / anomalies related to the fuel systems on their R44 helicopter, including if they have any findings from PRV inspections (refer RHC R44 Maintenance Manual). Please report findings to the CAA by completing a CA005 Defect Report form. Please provide as much engineering detail as possible. This will enable us to determine the extent of any issue with the PRVs and the R44 fuel system.

The form can be obtained from: https://www.aviation.govt.nz/assets/forms/CA005D_Form.pdf The completed form can be emailed to the CAA at: ca005@caa.govt.nz

CAN Template: Rev 1 October 2021

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