Air Accident Investigation Unit Ireland

SYNOPTIC REPORT

SERIOUS INCIDENT
Robinson R44 Raven II, EI-DDA
Ringaskiddy, Co. Cork
18 August 2014

An Roinn Iompair Turasóireachta agus Spóirt
Department of Transport, Tourism and Sport

Foreword

This safety investigation is exclusively of a technical nature and the Final Report reflects the determination of the AAIU regarding the circumstances of this occurrence and its probable causes.

In accordance with the provisions of Annex 13[1] to the Convention on International Civil Aviation, Regulation (EU) No 996/2010[2] and Statutory Instrument No. 460 of 2009[3], safety investigations are in no case concerned with apportioning blame or liability. They are independent of, separate from and without prejudice to any judicial or administrative proceedings to apportion blame or liability. The sole objective of this safety investigation and Final Report is the prevention of accidents and incidents.

Accordingly, it is inappropriate that AAIU Reports should be used to assign fault or blame or determine liability, since neither the safety investigation nor the reporting process has been undertaken for that purpose.

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[1] **Annex 13**: International Civil Aviation Organization (ICAO), Annex 13, Aircraft Accident and Incident Investigation.
[2] **Regulation (EU) No 996/2010** of the European Parliament and of the Council of 20 October 2010 on the investigation and prevention of accidents and incidents in civil aviation.
[3] **Statutory Instrument (SI) No. 460 of 2009**: Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulations 2009.

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In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No 996/2010 and the provisions of SI 460 of 2009, the Chief Inspector of Air Accidents on 18 August 2014, appointed Mr Paul Farrell as the Investigator-in-Charge to carry out an Investigation into this Serious Incident and prepare a Report.

Aircraft Type and Registration:	Robinson R44 Raven II, EI-DDA
No. and Type of Engines:	1 x Lycoming IO-540-AE1A5
Aircraft Serial Number:	10105
Year of Manufacture:	2003
Date and Time (UTC[4]):	18 August 2014 @ 13.30 hrs
Location:	Ringaskiddy, Co. Cork
Type of Operation:	Commercial Air Transport/ Training Flight
Persons on Board:	Crew - 2 Passengers - 0
Injuries:	Crew - 0 Passengers - 0
Nature of Damage:	Airframe undamaged, engine sustained substantial damage
Commander's Licence:	Commercial Pilot Licence (CPL) issued by the United Kingdom Civil Aviation Authority (UK CAA)
Commander's Details:	Male, aged 51 years
Commander's Flying Experience:	5,868 hours, of which 1,855 were on type
Notification Source:	Air Traffic Control (ATC), at Cork Airport (EICK)
Information Source:	AAIU Report Form submitted by the Pilot, AAIU Field Investigation

[4] **UTC**: Co-ordinated Universal Time. All times in this report are in UTC (local time minus one hour on the date of the accident).

SYNOPSIS

The helicopter was on a training flight from Cork Airport. During the en route phase, in the vicinity of Ringaskiddy, Co. Cork, the Pilot felt vibration accompanied by low rotor Revolutions Per Minute (RPM) warnings. The Pilot broadcast a "Mayday" transmission to ATC and made a successful autorotation[5] into an agricultural field. There were no injuries. The Investigation found that the helicopter's engine suffered a gross mechanical failure and the engine sustained substantial damage during the event.

NOTIFICATION

ATC personnel at EICK contacted the AAIU to advise of the event. The AAIU spoke by telephone with the Pilot while he was at the site of the landing. The AAIU also spoke with emergency services personnel who were attending the scene.

Initial reports referred to the vibration experienced; there was no mention of RPM warnings or of any difficulties during the autorotation. Consequently, the AAIU considered this to be a precautionary landing and gave permission for the Owner to carry out a photographic survey of the aircraft and the landing site and to recover the aircraft.

When the AAIU received the Pilot's written report it became clear that the event was more serious than the initial report had indicated and an investigation was initiated.

1. FACTUAL INFORMATION

1.1 History of the Flight

The helicopter departed EICK on a local training flight. While in the en route phase the Pilot reported to Cork ATC that there was a vibration in the helicopter.

The Pilot reported that the clutch light illuminated and this was accompanied by the low RPM warning light and horn. He said that he immediately commenced an autorotation and made a "Mayday" call. He selected a large field which he deemed a suitable site for his planned emergency landing and he manoeuvred the helicopter towards it.

At approximately 500 feet the Pilot stated that he noticed cables in the intended landing area. He "flared" the aircraft slightly to guide the helicopter over the cables. The helicopter was now reported to be heading towards a low hedge with some large trees. The Pilot said that he took avoiding action and aimed the helicopter between the trees and "flared" again to extend his glide over the hedge.

The helicopter cleared the hedge and landed heavily on a down slope where it slid for approximately two to three metres before coming to a rest in an upright orientation.

[5] **Autorotation**: A procedure in which a helicopter rotor is driven solely by the relative motion of air acting on its rotor blades as the helicopter descends without engine power.

The Pilot made a radio call to ATC to inform them that he had landed safely, that there were no injuries and to report his location. ATC were unable to receive his call so his message was relayed by another aircraft, which ATC acknowledged.

The Emergency Locator Transmitter (ELT) activated automatically during the landing and the Pilot shut this off manually. The Pilot also reported that he turned off all switches. He said that the engine did not need to be shut down as it was already stopped and so he turned off the fuel shut-off valve.

The Pilot then called ATC by telephone and informed them that no one was injured and that he had landed safely.

1.2 Reporting and Investigation

The AAIU was advised about the event by Cork ATC. The Pilot's initial telephone report only referred to vibrations and an autorotation. Consequently, the AAIU advised the Operator that, following a photographic survey of the aircraft at the landing site, the aircraft could be removed from the field for further investigation by the Operator and that the AAIU was to be informed of the findings. However, on receipt of the Pilot's written report, the references to obstacle avoidance manoeuvres during the autorotation and the fact that the engine did not need to be shut down by the Pilot, prompted the AAIU to commence an investigation. On contacting the Operator it was discovered that the engine was not turning freely and that the oil filter, which had been cut open for inspection, revealed evidence of significant metallic deposits.

When the AAIU initiated the Investigation the Owner was in the process of selling the damaged helicopter. At the Owner's request the AAIU agreed that the engine could be removed (by the Owner) and shipped to a UK based overhaul facility which held a European Aviation Safety Agency (EASA) Part 145 approval. The overhaul facility had not been involved in maintaining the engine previously. The AAIU arranged with the overhaul facility that the engine would be quarantined on arrival and the inspection would only commence under the supervision of the AAIU. When the engine arrived at the overhaul facility the Investigation was contacted to advise that the engine accessories had not been delivered with the engine. The Investigation contacted the Owner to request that the accessories be provided and they were delivered to the overhaul facility before the strip inspection. The following accessories were supplied:

- Magneto x 2
- Ignition Harness x 2
- Engine driven fuel pump x 1
- Fuel injector x 1
- Starter motor x 1
- Alternator x 1

1.3 Engine strip inspection

Two Inspectors of Air Accidents attended the overhaul facility to observe the engine strip inspection.

The engine was mounted on an inspection stand and it was confirmed that it was seized and would not rotate.

The engine oil filter element was examined and showed evidence of significant deposits of a material with a copper/phosphor bronze colour (**Photo No. 1**). Samples of the material were taken for metallurgical analysis.

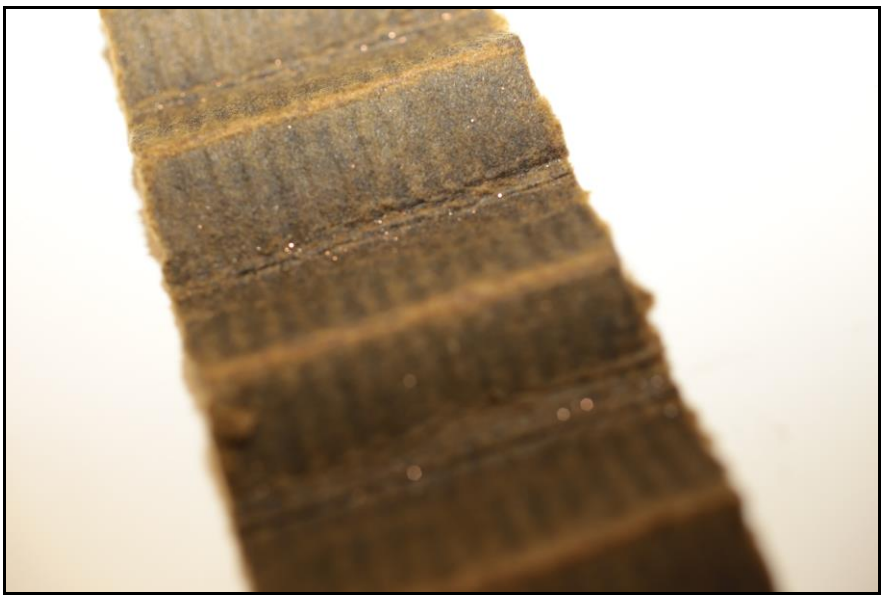

Photo No. 1: Metallic deposits on oil filter element

Cylinders Number 1, 2, 5 and 6 were removed and no evidence of damage was noted on any of them or on their associated components.

The oil sump was removed and a large amount of metallic debris was observed **(Photo No. 2**). The debris was examined and found to fit into three main categories:

1. Large sections of phosphor bronze which appeared to be from a small end bushing.
2. Pieces of steel which appeared to be from sections of a connecting (con) rod and con rod small end (**Photo No. 3** and **Photo No. 4**).
3. There were also pieces of aluminium alloy suspected to be fragments of the crankcase.

No defects were noted with the sump itself, and lubricating oil was in evidence.

Photo No. 2: Metallic debris deposited in the oil sump

Photo No. 3: Pieces of small end bushing retrieved from the oil sump

Photo No. 4: Pieces of the con rod/small end retrieved from the oil sump

The accessory housing was removed and the internal bolt-on oil pump assembly was examined. Oil was in evidence throughout the pump body and accessory housing oil galleries. The oil pump body and gears showed evidence of mild scoring commensurate with smaller metal particles, not trapped by the scavenge filter, circulating through it.

The cylinder in the Number 4 position was removed with great difficulty. Upon removal the reason for the difficulty was identified as damage to the Number 4 cylinder barrel skirt and to the bottom section of the Number 4 piston.

It then became apparent that the Number 3 cylinder con rod had failed catastrophically, generating a significant amount of metallic debris and causing severe damage to the casing and to the Number 3 and Number 4 cylinders.

On examination it was noted that the Number 3 piston was still in the Number 3 cylinder. Due to distortion and damage caused by the failure of the Number 3 con rod it was not possible to remove either the Number 3 piston or the Number 3 cylinder.

The Investigation was anxious to examine the Number 3 piston crown and the condition of the Number 3 cylinder valves. Con rods were removed from cylinders 1, 2, 4, 5 and 6 to facilitate crankcase splitting with the Number 3 cylinder still attached. The affected crankcase half was taken to an engineering workshop where the cylinder barrel was cut with an angle grinder, as close to the crankcase as possible. This allowed the piston to be removed and the piston and cylinder to be examined. No indications of overheating were found on the cylinder, piston crown, inlet or exhaust valves. The bottom of the piston exhibited impact damage consistent with the failure of the con rod (**Photo No. 5**).

Photo No. 5: Damage to the bottom of the Number 3 piston

The surface of the piston pin for the Number 3 piston exhibited mechanical distress. None of the other piston pins or small end bushings exhibited evidence of distress.

A small section of the Number 3 con rod remained attached to the crankshaft journal. This section was in contact with the crankshaft web and consequently was incapable of rotation (**Photo No. 6**).

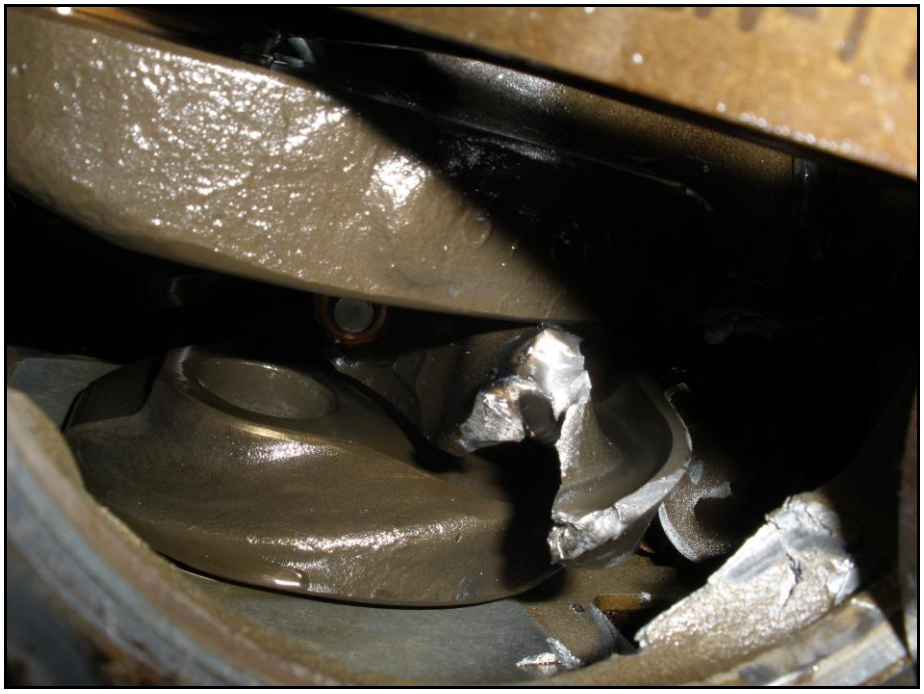

Photo No. 6: Section of the Number 3 con rod, still attached to the crankshaft, in contact with web

The section of the Number 3 con rod which was still attached to the crankshaft was removed and, for comparison, aligned with the section recovered from the engine sump (**Photo No. 7**).

Photo No. 7: Both sections of the failed con rod

The overhaul facility noted that there were sufficient quantities of oil contained within the engine and the critical internal components (including big end journals) and that no evidence was observed which suggested incorrect/poor maintenance.

The overhaul facility reported that it appeared that the Number 3 small end bushing had deteriorated over an indeterminate period of time until an excessive amount of clearance was present between the Number 3 small end bushing and the Number 3 piston pin. This excessive clearance initiated the failure sequence during which the con rod was overloaded and failed. Subsequently, flailing of the failed con rod parts caused extensive secondary damage to the casings and the Number 3 and 4 cylinder skirts.

1.4 Metallurgical Testing

The samples of the metal particles that were recovered from the oil filter, and a portion of the failed small end bushing were sent to a metallurgical facility for a comparison analysis. This analysis concluded that the particles were a good match for the bushing material.

1.5 Maintenance Records

According to the Engine Log Books, the engine's date of construction was 14 May 2003 and it entered service on 2 September 2003.

On 7 August 2013, the Engine Manufacturer (Lycoming) published Service Instruction No. 1009AV (superseding Service Instruction No. 1009AU). This Service Instruction set out "*Recommended Time Between Overhaul Periods*" for all Lycoming piston aircraft engines. For the subject engine model (IO-540-AE1A5) the Manufacturer's recommended Time Between Overhaul (TBO) period was 2,000 hours. Engine Log Books show that on 22 February 2014 the engine had accumulated 1,955.9 hrs "*Time Since New or Complete Overhaul*". On 24 February 2014 the Engine Manufacturer published Service Instruction No. 1009AW (superseding Service Instruction No. 1009AV). This Service Instruction set the TBO for the subject engine model at 2,200 hours. The Log Book entry for the date of the event gives the "*Time Since New or Complete Overhaul*" as 2,122.9 hours.

Examination of the Maintenance Records revealed no anomalies and there were no reported problems with the engine at the time of the event.

It was noted that on 23 September 2009 the same aircraft/engine had an event involving a loss of oil pressure. The engine was sent to an EASA part 145 approved overhaul facility where extensive work was carried out including replacement of two cylinders and de-glazing of the other four cylinders. The work was recorded in the aircraft Log Books and following completion of the work an EASA Form One (official release to service certification) was issued for the engine.

The Engine Manufacturer asked the Investigation to enquire if the "sniffle" valve[6] had been tested. As the engine was shipped by the Owner, and the accessories supplied separately, the Investigation contacted the Owner to ascertain the whereabouts of the "sniffle" valve.

[6] **"Sniffle" valve**: is a drain valve fitted to the engine's intake manifold to remove excess fuel from the manifold.

He was unable to say where the valve was but said that apart from the items sent to the overhaul facility for the Investigation's examination, everything else had been shipped to the new owner, either attached to the helicopter airframe or in an associated packing crate.
The new owner was contacted and he advised that he had not received a "sniffle" valve with the aircraft and that he had actually purchased one to return the aircraft to service. The facility which stripped the engine advised the Investigation that it had seen many cases of unserviceable sniffle valves on engines which exhibited no ill effects. It also advised that a common effect it had seen with unserviceable "sniffle" valves was evidence of intake fire damage and that no such damage was in evidence on the subject engine.

1.6 Maintenance Organisation

A UK-based Maintenance Organisation (MO) was responsible for maintaining the helicopter and engine since May 2012. The MO held EASA Part 145 aircraft Maintenance approval and EASA Part M Sub-part G Continuing Airworthiness Management approval, both of which were issued by the UK CAA. On 5 August 2014 the MO surrendered its approvals to the UK CAA. All maintenance records presented to the Investigation for EI-DDA pre-date 5 August 2014.

2. ANALYSIS

During the en route phase of flight the helicopter suffered a catastrophic engine failure which necessitated an autorotation landing. The Pilot selected the field he deemed most suitable but was forced to make two adjustments to his flight path to avoid cables, a hedge and some trees. During the autorotation the engine stopped without Pilot intervention.

Significant deposits of a copper/phosphor bronze coloured material were recovered from the oil filter. Metallurgical comparison of the filter deposits and the remnants of the Number 3 small end bushing which were recovered from the sump case, revealed a good match.

The engine was stripped, at an approved facility, in the presence of two AAIU Inspectors. It was identified that the Number 3 con rod had fractured, thereafter causing significant secondary damage to the Number 3 and 4 cylinder barrels and to the crankcase. It appeared that the Number 3 small end bushing had deteriorated over an indeterminate period of time until an excessive amount of clearance was present between the Number 3 small end bushing and the Number 3 piston pin. This excessive clearance initiated a sequence of events during which the con rod was overloaded and failed. Subsequently, flailing of the failed con rod parts caused extensive secondary damage to the crankcase and the Number 3 and 4 cylinder skirts.

Fragments of the Number 3 small end bushing were found in the crankcase oil sump. The surface of the piston pin for the Number 3 piston exhibited evidence of distress. None of the other piston pins or small end bushings exhibited evidence of distress.

Lycoming Service Instruction No. 1009AW specifies 2,200 hours as the recommended TBO for the subject engine model (IO-540-AE1A5). The Investigation notes that Service Instruction No. 1009AW supersedes Service Instruction No. 1009AV which specified a TBO of 2,000 hours. Maintenance records presented to the Investigation showed that on the day of the event the engine had accumulated 2122.9 hours "*Time Since New or Complete Overhaul*". Therefore, at the time of the event the subject engine was within the Manufacturer's recommended TBO.

The overhaul facility where the engine was stripped reported that no evidence was observed which suggested incorrect/poor maintenance. Although the sniffle valve was not available for testing, there was no evidence of intake fire which would be consistent with an unserviceable sniffle valve.

3. CONCLUSIONS

(a) Findings

1. The engine suffered a catastrophic in-flight failure.
2. The Pilot executed a successful autorotation landing during which two obstacle avoidance manoeuvres were carried out.
3. No anomalies were noted with the aircraft aircraft's Maintenance Records and there were no reported problems with the engine at the time of the event.
4. Stripping of the engine revealed that the Number 3 con rod had fractured, thereafter causing significant secondary damage to the Number 3 and 4 cylinder barrels and to the crankcase.
5. Metallurgical testing showed that metal particles that were recovered from the oil filter were a good match for the con rod small end bushing material.
6. The Number 3 small end bushing had deteriorated over an indeterminate period of time until an excessive amount of clearance was present between the Number 3 small end bushing and the Number 3 piston pin; this excessive clearance initiated a sequence of events during which the con rod was overloaded and failed.
7. Flailing of the failed con rod parts caused extensive secondary damage to the crankcase and the Number 3 and 4 cylinder skirts.
8. Fragments of the Number 3 small end bushing were found in the crankcase oil sump and the surface of the piston pin for the Number 3 piston exhibited evidence of distress.
9. None of the other piston pins or small end bushings exhibited evidence of distress.
10. The reason for the deterioration of the Number 3 small end bushing could not be determined.
11. The subject engine had accumulated 2,122.9 hours "*Time Since New or Complete Overhaul*" which was within the Manufacturer's recommended TBO of 2,200 hours.

(b) Probable Cause

1. Deterioration of the Number 3 small end bushing over an indeterminate period of time.

4. SAFETY RECOMMENDATIONS

The Investigation does not sustain any safety recommendations.

- END -

In accordance with Annex 13 to the Convention on International Civil Aviation, Regulation (EU) No. 996/2010, and Statutory Instrument No. 460 of 2009, Air Navigation (Notification and Investigation of Accidents, Serious Incidents and Incidents) Regulation, 2009, the sole purpose of this investigation is to prevent aviation accidents and serious incidents. It is not the purpose of any such investigation and the associated investigation report to apportion blame or liability.

A safety recommendation shall in no case create a presumption of blame or liability for an occurrence.

Produced by the Air Accident Investigation Unit

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