

**AAIB Bulletin No:** 10/94

**Ref:** EW/C94/6/2

**Category:** 2.3

**Aircraft Type and Registration:** Robinson R22 Beta, G-PUDD

**No & Type of Engines:** 1 Lycoming O-320-B2C piston engine

**Year of Manufacture:** 1988

**Date & Time (UTC):** 8 June 1994 at 1139 hrs

**Location:** Near Martin, Hampshire

**Type of Flight:** Private (Training)

**Persons on Board:** Crew - 2                      Passengers - None

**Injuries:** Crew - Fatal                      Passengers - N/A

**Nature of Damage:** Aircraft destroyed

**Commander's Licence:** Airline Transport Pilot's Licence (Helicopters and Gyroplanes) with Instructor's Rating

**Commander's Age:** 46 years

**Commander's Flying Experience:** 8,257 hours (of which 7,170 hours were on Helicopters and 5,200 were on type)  
Last 90 days - 111 hours  
Last 28 days - 48 hours

**Information Source:** AAIB Field Investigation

The student pilot was the holder of an Airline Transport Pilot's Licence (Aeroplanes) and was employed as a pilot. He had more than 4,000 hours total flying experience which included approximately 40 hours in a gyroplane. He had also completed 22 hours on his Private Pilot's Helicopter course; all his flying on the course had been on the R22 Beta, and all with the same instructor. For the accident flight there was no documentary evidence of what the flight would entail. The briefing between the instructor and the student lasted for just over 1 hour and, during it they had been overheard discussing helicopter safety and the Sloane Helicopters Safety Course; additionally, the instructor was heard to emphasise the importance of reacting correctly to helicopter emergencies and the fact that this reaction was sometimes unnatural for a fixed wing pilot. As the crew left the operations room, the instructor was heard to say to the student that they would be doing some "engine-offs". The student's training records indicated that they had practised engine-off landings on 6 previous occasions; the records also indicated that they had previously covered basic and advanced autorotations and forced landings, and that the student had been doing very well in his training.

The weather for the flight was good with an unstable north-westerly airstream covering the area. There was some scattered cumulous, base 3,000 to 4,000 feet amsl, and the visibility was greater than 25 km; the surface wind was 330°/15 to 20 kt and the wind at 2,000 feet was 320°/20 kt.

After leaving the operations room the crew called Bournemouth ATC at 1116 hrs and hover-taxed to the departure area. A normal departure was made at 1117 hrs and the aircraft set course to the north. The final call to ATC was made at 1122 hrs as G-PUDD passed Verwood. There were no further calls recorded from the aircraft and no recorded radar information. Various witnesses in the area of Martin, Hampshire saw the helicopter in the last stages of flight and one reported seeing it flying level at an estimated 1,000 feet agl. This witness stated that as he looked at the helicopter, he saw a piece come off "just below the large rotor blade and went directly back towards the little blade at the back"; he then saw the helicopter continue straight ahead for a short period before it nose-dived to the ground. As it descended it was rotating. He saw the main rotor still turning and then saw some bits come off the helicopter before it went out of his sight behind a hill; this witness was approximately 1 mile away. The other witnesses saw the helicopter as it was descending; they all stated that their attention was drawn by a spluttering noise from the engine. As the helicopter was spiralling towards the ground, the rotor blades appeared to be rotating slowly and then seemed to be stationary; there was no smoke or flame and other parts of the aircraft appeared to fall after the main wreckage had impacted the ground; the impact point was at 300 to 400 feet amsl. Some of the witnesses reported seeing other aircraft in the area but subsequent inquiries with ATC and the pilots revealed no relevant information.

A post-mortem report revealed no evidence of any medical condition which may have contributed to the accident.

### **Engineering Examination**

The main wreckage of the helicopter comprised the fuselage and about 50% of the tail boom which had crashed inverted in a field of natural meadow. It was evident that it had fallen almost vertically at a high descent rate but with little or no forward speed. The main rotor and mast had detached shortly before impact and was found about 25 metres downwind of the main wreckage. Further downwind were located the two cabin doors, each having detached apparently due to disconnection of the lower hinge followed by wrenching-out and failure of the upper hinge structure.

Slightly further back along the reported track of the aircraft and again downwind were the tail rotor and empennage together with several pieces of the tail boom. Fuel contamination of the grass around the main wreckage indicated that the helicopter had been carrying a considerable quantity of fuel. It became clear, as the helicopter was righted, that the carburettor hot-air control knob was extended for about two-thirds of its normal travel. Despite the inverted impact, it had not been deformed and, in

fact, could still be operated such that the sliding plate in the inlet filter box moved. The latter had, detached from the carburettor and stretched the outer operating cable. Faint witness marks on the sliding plate did, however, suggest that at the moment of ground impact it was in the 'cold air' selection.

The aircraft was recovered to the AAIB hangar at Farnborough, although it became apparent that at least two items could not be located - the tail rotor driveshaft and one of the main rotor pitch links. Despite the eyewitness report, however, there appeared to be no piece large enough to have been visible from his location which was not found in the area described above.

AAIB inspection of the wreckage was supplemented by a team from the US National Transportation Safety Board (NTSB), The Federal Aviation Administration (FAA) and a representative from the Robinson Helicopter Company. It was apparent that the main rotor blades had drooped sufficiently in flight to strike the tail boom twice, causing complete disruption of the boom and liberating the empennage and tail rotor assembly. Detailed examination of the flying controls, structure and transmission did not reveal any pre-accident abnormalities and there were no signs of major mechanical problems with the engine, although it was clearly stationary at impact.

### **Additional Information**

The damage to the tail boom bore strong resemblance to that suffered by G-BSHF (HF), an R22 which crashed at Welford-on-Avon, Warwickshire, on 8 September 1991 and was reported in AAIB Bulletin 12/91. In the case of 'HF', however, there were also signs of a low energy blade strike on the cockpit canopy perspex. Because G-PUDD (DD) had crashed inverted, any such evidence was obscured. Again, in the case of 'HF', one main rotor blade detached before impact, whereas the entire mast had separated by fracturing the top of the main rotor gearbox case on 'DD'. Metallurgical examination showed that this latter fracture was caused by 'whirl' forces as might be experienced with a severely eccentric or out-of-balance main rotor. In both cases, however, no engineering reason was found which could account for the apparent flap-down of the main rotor which caused the strikes on the boom.

The aforementioned Bulletin 12/91 reprinted two Robinson Helicopter Company Safety Notices (SN), Nos SN-10 and SN-11 which deal with two possible handling problems which could lead to contact between the main rotor and the tail boom. The former SN discusses the phenomenon of low rotor RPM, particularly with respect to real or practice engine failures, which can lead to rotor stall. The SN states:

*When it stalls, the blades will either 'blow back' and cut off the tail cone, or, it will just stop flying allowing the helicopter to fall at an extreme rate.*

The latter case seems to have applied to G-BPPC, an R22 Mariner helicopter which crashed near Oldham on 23 February 1992 for which video evidence shows the machine dropping vertically with the rotor blades stationary. There had, however, been no rotor strikes on the tail boom or canopy. This accident was reported in AAIB Bulletin 5/92

Safety Notice SN-11 deals with the effects of 'low g' manoeuvring such as may be caused by a 'pushover' application of forward cyclic control. Application of lateral cyclic to attempt to counter the ensuing roll to the right before regaining normal loading can result in catastrophic 'mast-bumping' (contact between the blade root and the mast). The SN states:

*If the pilot attempts to stop the right roll by applying full left cyclic before regaining main rotor thrust, the rotor can exceed its flapping limits and cause structural failure of the rotor shaft.*

Although the two SNs deal with different phenomena it can be difficult to differentiate between the two during post-accident examination of the hardware. In the opinion of the manufacturer's representative, mast-bumping tends to leave more evidence of repeated contact between the blade root and the mast. However, except in those cases where RPM is simply lost (G-BPPC), both phenomena imply downwards overtravel of at least one of the blades causing gross exceedence of the droop stop limits. In the case of 'DD', the degree of overtravel had been sufficient to break both pitch links and the droop stops before contact between the blade root and the mast caused a pronounced bend at the top of the shaft, but without breaking it.

Metallurgical examination of the gears removed from the Main Rotor Gearbox revealed no significant defects but did note that there were markings on the drive side flanks of the pinion teeth which indicated that the mating crownwheel and pinion gears had run 'for a very short period under abnormally high loads'. This might indicate that the engine was developing power against a rapidly slowing rotor and suggests that the events which led to the rotor hitting the tail boom and slowing down (but not necessarily in that order) were not precipitated by an engine failure.

### **National Transportation Safety Board (NTSB) Safety Recommendations**

On 21 July 1994, the US NTSB issued two safety recommendations, A-94-143 and A-94-144, concerning the Robinson R22 flight characteristics. The preamble to the recommendations details the accident to G-PUDD and two others in the US as examples of unexplained 'main rotor divergent behaviour'. Additionally, the recommendation lists some 18 other cases in which in-flight break-up occurred which they also believe 'indicated that there may be undesirable aerodynamic characteristics

of R22 main rotor blades that can result in one or both blades diverging from their normal plane of rotation'. The preamble also expresses the concern that, since some of the accidents were known to have occurred in normal cruising flight, the divergent rotor behaviour may be related to forward speed. Accordingly, the following recommendations were made:

*...the National Transportation Safety Board recommends that the Federal Aviation Administration:*

*Issue an immediate airworthiness directive to reduce the Robinson R22 helicopter "never exceed airspeed" ( $V_{ne}$ ) to an airspeed that would provide an adequate margin of operating safety below the airspeeds at which loss of main rotor control accidents have occurred, until the reason for in-flight main rotor blade divergent behaviour is established and design changes are approved and implemented, as necessary. (Class I, Urgent Action) (A-94-143).*

*In conjunction with the National Aeronautics and Space Administration and Robinson Helicopter Company, conduct wind tunnel and modelling tests to examine flight parameters of the R22 helicopter to determine the helicopter's design characteristics that are related to main rotor divergent behaviour; and if any abnormal rotor system performance characteristics are found, take the necessary actions to assure proper dissemination of the information and to modify the R22 design. (Class I, Urgent Action) (A-94-144).*

A formal reply to the NTSB recommendations is required from the FAA within 90 days. Following these recommendations, on 22 July the FAA issued a Special Airworthiness Alert containing procedures to reduce the possibility of accidents resulting from main rotor/fuselage contact and wire strikes involving R22 and R44 helicopters. The contents of this Alert, and associated CAA comments, were published in the General Aviation Safety Information Leaflet (GASIL) in August 1994.