Robinson R44 Astro, G-URUH

AAIB Bulletin No: 11/2003	Ref: EW/C2002/10/02	Category: 2.3
Aircraft Type and Registration:	Robinson R44 Astro, G-URUH	
No & Type of Engines:	1 Lycoming O-540-F1B5 piston engine	
Year of Manufacture:	1997	
Date & Time (UTC):	19 October 2002 at 1304 hrs	
Location:	Woofferton, Shropshire	
Type of Flight:	Private	
Persons on Board:	Crew -1	Passengers - None
Injuries:	Crew - 1 (Serious)	Passengers - N/A
Nature of Damage:	Aircraft destroyed	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	40 years	
Commander's Flying Experience:	Information not provided by commander	
Information Source:	AAIB Field Investigation	

Synopsis

The helicopter suffered a partial or complete power loss resulting in an autorotative descent and forced landing. The rate of descent and forward speed at touchdown were high resulting in the helicopter suffering damage and rolling over. There was no post impact fire. On site checks revealed that there was no fuel in the fuel lines or gascolator bowl and very little fuel was found in the fuel tanks.

History of flight

On the morning of the accident the pilot, who was also the owner of the helicopter, arrived at Denham Airfield, Buckinghamshire and after spending some time in the clubhouse went out to the helicopter, which was parked on a grass area nearby, and attempted to start the engine so that he could hover taxi to the fuel pumps. He experienced some difficulty with starting and requested assistance from an instructor. The helicopter was eventually started and the pilot hovered taxied to the fuel pumps where he asked for the tanks to be filled. The refuelling was carried out in his presence and the refueller later confirmed that both tanks, main and auxiliary, were refuelled to full. After refuelling the pilot entered the helicopter and prepared to depart. He did not carry out any further visual check of the fuel tank contents or operate the fuel strainers.

The pilot 'booked out' on the radio before departure, giving his destination as Newport, South Wales. It was understood to have been his intention to return to Denham later the same day. The Global Positioning System (GPS), fitted to the helicopter, recorded that he departed Denham at 0842 hrs and flew on a direct track to a private landing site at Newport arriving at 0950 hrs. His altitude en-route varied between 1,200 and 2,300 feet.

The GPS recorded that the helicopter became airborne from Newport at 1148 hrs and flew to Aberystwyth, Wales, maintaining en-route altitudes of between 2,000 and 3,000 feet. Near Aberystwyth it descended to a low altitude over the sea before climbing again and tracking in a generally easterly direction for the remainder of the flight. At 1256 hrs the pilot made a radio call to Shobdon Tower advising that he was en-route from Aberystwyth to Worcester and requested permission to transit the Aerodrome Traffic Zone (ATZ). At 1300 hrs he transited the Shobdon overhead at an altitude of 1,400 feet. Three minutes later the helicopter began to lose power and the pilot put it into an autorotative descent. The rate of descent was calculated to have averaged 1,000 ft/min. The forced landing area was a level field with a smooth but soft earth surface. The helicopter hit the ground hard on an easterly heading, in a level attitude with significant forward speed and rolled over onto its side. The pilot was injured in the impact but was able to escape from the wreckage, cross a ditch, climb a bank and reach a nearby road where a passing motorist stopped and gave assistance.

Meteorological conditions

A meteorological aftercast, giving the synoptic situation at 1200 hrs, showed that the southern half of England and Wales was under the influence of a high pressure, centred over France. This resulted in a generally stable westerly airflow over the region.

The 1300 hrs automated meteorological observation at Shobdon Airfield gave the surface wind as 250°T/7kt, visibility 45 km, temperature 11°C/ dewpoint 3°C, QNH 1019 mb and cloud as broken at 6,000 feet. Pilot reports from the area indicated that conditions were smooth with good visibility.

Pilot experience

The pilot first obtained his Private Pilot's Licence for helicopters in 1996. Since then he had owned several helicopters which he had flown on a regular basis. At the time of publication the pilot had not provided the AAIB with details of his experience.

Aircraft information

Fuel system

The fuel system consists of two separate tanks, main and auxiliary, with a combined total useable fuel capacity of 48.9 USG (185 litres). The auxiliary tank is smaller than the main, and its bottom face is above that of the main tank. The two tanks are interconnected by a fuel line that feeds the contents of the auxiliary tank into the main. The main tank then feeds by gravity, through a shut off valve and a gascolator, directly to the carburettor. Each tank is fitted with a float type fuel quantity sender. The main tank also has a low fuel switch which consists of a float operated reed switch. There are no mechanical or electrical pumps in the fuel system.

There are two fuel gauges located on the instrument console in the cockpit, one for the auxiliary tank and one for the main tank. The design of the fuel system is such that, as fuel is consumed, the level in each tank drops equally until the auxiliary tank is drained. The auxiliary fuel quantity gauge should read zero in this case, with the gauge for the main tank indicating the remaining fuel. Further fuel use will cause the main fuel quantity gauge indication to reduce towards zero. When there are only 3.2 to 3.6 USG (12 to 13.5 litres) of fuel remaining, the low fuel switch should operate, illuminating a red low fuel light on the instrument panel beneath the glareshield.

Management of the fuel system is limited to selecting fuel 'ON' or 'OFF'. The carburettor float chamber should control the head of fuel to the venturi, so that the first indications from the engine of lack of fuel, will occur when the fuel line to the float chamber becomes empty.

Performance

The helicopter's Pilot's Operating Handbook (POH) does not contain any information about the fuel consumption or endurance, neither is it required to do so. Some of the sales literature however, quotes 14 USG/hr. In practice an estimated fuel burn is calculated from observing previous flights

and fuel usage. This helicopter was fitted with a carburettor (part number 10-6035-11) which was introduced to reduce fuel consumption. It is expected to reduce consumption by about 2 USG/hr in the cruise, however the use of full carburettor heat could increase consumption by 2 USG/hr or more. The helicopter was normally operated with the mixture control in the full rich position. From the experience of others and his own previous experience it was anticipated by the pilot that under normal operating conditions, starting with full tanks, the helicopter would have an endurance of 180 to 185 minutes.

The helicopter was fitted with an hour meter that recorded elapsed time whenever collective pitch was applied. This was the means by which flight times were recorded in the technical log and subsequently against which fuel burn was measured. This meter is located in the cockpit low down on the right sidewall.

The POH section titled '*Safety Tips'* contains Safety Notice SN-15 titled '*Fuel Exhaustion Can Be Fatal'* that cautions pilots on the hazards associated with running out of fuel and suggests precautions that should be taken to avoid doing so. The following precautions are recommended while the helicopter is in flight:

> *'Continually check both hourmeter and fuel gauges. If either indicates low fuel, LAND.*
>
> *Always land to refuel before the main tank fuel gauge reads less than 1/4 full.*
>
> *NEVER allow the fuel quantity to become so low in flight that the low fuel warning light comes on.'*

The manufacturer's recommended speed for autorotation is around 70 kt.

Engineering investigation

The helicopter was fitted with a Skyforce CM/CT 2000 Global Positioning System (GPS) that recorded position and altitude throughout the accident flight. The GPS showed that the helicopter had been in flight for a total of 2 hours 21 minutes which compared well with the hourmeter that recorded 2.4 hours of elapsed time.

From the ground marks it could be seen that the helicopter had struck the ground in a reasonably level, well flared attitude, on a magnetic track of about 110 degrees. It had struck the tail rotor during the initial touchdown and travelled approximately 30 metres before coming to rest. The rate of descent was high enough to cause the progressive collapse of the landing skids. The damage to the skids was consistent with that intended to improve crashworthiness in a heavy landing and minimise occupant injury. After initial touchdown the helicopter had bounced, with a second heavy touchdown on the nose. During the rapid pitch change from nose high to nose down, the main rotor had struck the tail boom. Parts of the tail boom and tail rotor system were found about 60 metres from the main wreckage, indicating reasonably high main rotor energy at touchdown.

Before the helicopter was moved from the accident site, checks of the fuel lines and gascolator bowl were made. No fuel was found in the gascolator or the fuel lines.

A more detailed examination was carried out at the AAIB facility at Farnborough. The engine was not badly damaged in the impact and was free to turn with no evidence of any mechanical disruption. The engine accessory drive was checked to verify that both magnetos were being driven. The magnetos themselves were both found to work normally, and the plugs showed a normal tan colour. The filaments of the low RPM, low oil pressure and low fuel warning light were examined, but none of them showed any sign of stretching, that would have indicated that they were illuminated at the moment of impact. This however could be due to an impact of insufficient severity to affect the filaments. The fuel quantity indicating system and low quantity warning system wiring were inspected and several breaks in the wiring were found. These were examined and considered to be a result of the impact. With the connections remade, the electrical system was powered up, and both quantity gauges and the low quantity warning light were found to work normally.

Refuelling procedures and records

For the purpose of the investigation the recent history of fuel uplift and flight times was collected.

The following information was recorded on the fuel supplier's record sheets:

Date	Registration	Uplift AVGAS (Litres)
11 Oct 2002	G-URUH	43.5
17 Oct 2002	G-URUH	60.0
19 Oct 2002	G-URUH	107.6

On the day of the accident the refueller had supplied fuel to several R44s and/or R22s. He recalled the pilot requesting that both tanks of G-URUH be filled to the top. He dispensed a total of 107.62 litres of 100LL AVGAS, and recorded that amount in his log. He normally did this by filling each tank until the nozzle cut off operated, and then topping off each tank. The filler caps on the R44 are high enough to make it difficult to see the fuel level. It is unclear how it was established that G-URUH was filled on this occasion. It is also unclear as to whether the pilot confirmed visually the contents of the fuel tanks before flight.

The following flight details were recorded in the helicopter technical log for the days preceding the accident flight:

Date	Fuel state at start of flight	From	To	DATCON elapsed time (hrs)
8 Oct 2002	Full	Denham	Denham	0.7
13 Oct 2002	Full	Denham	Hereford	1.0
13 Oct 2002	Not recorded	Hereford	Denham	1.1
17 Oct 2002	Not recorded, 60 litres added before flight	Denham	Denham	1.3

The information from the two tables was combined to calculate that the recent fuel burn approximated to 16 USG/hr (one litre per minute). By the same means it was calculated that, following the flight on 17 Oct 2002, the uplift required to achieve full tanks should have been approximately 144 litres. The actual uplift on 19 October was 107.6 litres, leaving a calculated shortfall of about 36 litres.

Discussion

The hourmeter and GPS recorded similar flight times of about 145 minutes. By allowing extra time for ground running and hovering it is difficult to account for more than 150 minutes of fuel useage. Thus if the helicopter did indeed depart Denham with full tanks there is an apparent shortfall of 30 to 35 minutes of fuel.

A number of possible explanations could be considered for the apparent lack of fuel at the accident site.

1. The original fuel uplift was not to full tanks. - The refueller, however, believed that he had filled the tanks.
2. Fuel could have been removed from the helicopter at Newport. - There is no evidence that this occurred.
3. The fuel burn en-route was much higher than expected. - There is no apparent reason why this should have been the case.

4. Fuel leaked from the helicopter in-flight. - There is no evidence of any leakage of fuel found during the investigation.

5. Fuel leaked from the helicopter following the accident. - There was no sign of fuel at the accident site and the fuel drain would have to have been activated by resting against a solid surface.

The refuelling records showed that insufficient fuel was uplifted to fill both of the tanks completely. A shortfall of some 36 litres remained giving a calculated endurance of 145 to 150 minutes. Although it is possible that some fuel was uplifted prior to the helicopter being refuelled on 19 October at Denham without being recorded, it is interesting to note that the shortfall closely agrees with the achieved endurance of the helicopter on the accident flight.

There are therefore a number of explanations that can account for the observed fuel discrepancies. The most likely explanation, that accounts for both the uplift shortfall and the lack of fuel on board at the time of the accident, is that the tanks were not refuelled to full before the helicopter left Denham.

Although there were a number of ways in which is was possible for the pilot to have monitored the fuel status en route he appears to have relied on his expected total endurance time. The fuel gauges were found to be functioning correctly, as was the low fuel light. This light is protected from sunlight by the glareshield but it is possible, with the sun at a low angle, that it could shine directly on the light reducing its level of perceived illumination.

It is not known if it was the pilot's intention to land and refuel before completing the return flight to Denham. The distance remaining to Denham was 100 nm or around one hour flight time. Shobdon Airfield lies approximately on the direct track between Aberystwyth and Denham but the pilot deviated to the north of the direct track after passing overhead Shobdon. The reason for the course alteration and the intentions of the pilot were not determined.

CAA General Aviation Safety Sense Leaflet 17B titled *'Helicopter Airmanship'* (published on the CAA website) provides general guidance to helicopter pilots. Section 3.9 '*Fuel planning*' includes the following recommendations:

'Always plan to land by the time the tank(s) are down to the greater of 1/4 tank or 45 minutes, but don't rely solely on the gauge(s) or low fuel warning.'

'Know the hourly fuel consumption of your helicopter. In flight, check that the gauge(s) agree with your calculations.'

The Bureau Enquetes-Accidents[1] publish a study entitled '*Fuel Starvation in General Aviation*'. The study identifies a number of factors which are common in accidents resulting from fuel starvation. Among these factors are; failure to record or erroneous information on refuelling in the flight logbook, failure to perform a complete fill-up when intended, and incomplete flight preparation with a fuel estimate calculated, or cut, to a very fine margin.

[1] Bureau Enquetes-Accidents web site: http://www.bea-fr.org