ACCIDENT

Aircraft Type and Registration:	Enstrom F-28A-UK, G-BAAU
No & Type of Engines:	1 Lycoming HIO-360-C1A piston engine
Category:	2.3
Year of Manufacture:	1972
Date & Time (UTC):	15 December 2004 at 1559 hrs
Location:	Corporation Lane, Coton Hill, Shrewsbury, Shropshire
Type of Flight:	Private
Persons on Board:	Crew - 1 Passengers - None
Injuries:	Crew - 1 (Minor) Passengers - N/A
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence
Commander's Age:	46 years
Commander's Flying Experience:	105 hours (all on type) Last 90 days - 14 hours Last 28 days - 8 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and subsequent enquiries by the AAIB

Synopsis

The pilot was on the return leg of a solo flight from Manchester to Nottingham when the engine suddenly cut out. He entered autorotation but the aircraft sustained extensive damage in the ensuing forced landing. On inspection it was found that the aircraft had run out of fuel. Investigation revealed that there was no appropriate data on fuel consumption rates in the helicopter's Flight Manual although some information existed in the Lycoming engine manual. The pilot did not possess a copy of the engine manual and had incorrectly based his fuel planning on the consumption rate witnessed on the aircraft's fuel flow gauge during previous flights.

History of the flight

The pilot planned to fly solo from the helicopter's home base at Barton Airport, Manchester, to Nottingham and then to return to Barton. The entire flight had a planned distance of 156 nm. The pilot intended to cruise at 80 mph indicated airspeed (69.5 KIAS) with a planned airborne time of two hours and twenty-four minutes. The weather forecast was good with only light north-westerly winds predicted. Before departure the pilot positioned the helicopter at the airport's refuelling point and asked the attendant to fully refuel both of the helicopter's fuel tanks. He then departed at 1150 hrs for the flight to Nottingham, flying at an altitude of about 1,500 ft and at his planned cruise speed of 80 mph. During the cruise the pilot noted that the fuel flow gauge indicated that the helicopter was consuming about 54 lbs/hr of AVGAS. He arrived at Nottingham Airport at 1312 hrs, having taken two minutes less than the planned flight time for this leg. On landing the fuel gauge showed three-quarters full.

Prior to his return flight the pilot again checked the forecast weather conditions and confirmed that he still had enough fuel on board, without refuelling, to complete the flight ba ck to Barton safely.

The pilot took off for the return flight at 1449 hrs and found himself flying into sun in hazy conditions. He had planned to use a mast situated on Carlton Moor as a navigational reference point. However, under the prevailing conditions, shortly after takeoff he mistakenly started to fly towards a different mast, situated on Darley Moor. The pilot realised his mistake some way into the flight and took several minutes to regain the correct track. When he had done so he recalled checking the fuel gauge which showed a quarter of a tank remaining. The pilot was then concerned that he might not have sufficient fuel on board to complete the remainder of the flight and he decided the safest option was to make a precautionary landing in order to allow him to re-calculate his fuel requirement. If necessary, he could then either plan to fly to a suitable diversion or organise for the helicopter to be refuelled where it was.

The pilot began heading towards an area of open fields in which he planned to land and had descended to a height of about 800 ft agl when, without warning, the engine stopped. The pilot immediately entered autorotation and looked for a suitable place to land. His choice of landing area was limited by his relatively low altitude plus numerous surrounding buildings and obstacles. The pilot identified what he considered the most suitable area, although it was relatively small and had power lines in the undershoot and some trees in the overshoot areas. As he got lower it was also apparent that the chosen landing area was in fact a small bowl and once over the wires, when flaring the helicopter for touchdown, the tail struck rising ground behind the machine. This tail strike broke off the tail rotor and rear portion of the tail boom, whereupon the remainder of the helicopter then struck the ground heavily, coming to an immediate halt. The pilot estimated his speed just prior to touchdown was 30 mph (26 kt). The helicopter remained upright, but the force of the landing was sufficient to burst open both cabin doors and to cause extensive damage to the rest of the machine.

The pilot injured his left shoulder during the impact, but otherwise he was unscathed. He made sure all the electrical switches were safe and in the absence of any fire, he remained in the helicopter whilst contacting the emergency services on his mobile telephone. He then climbed out of the helicopter to await their arrival.

A subsequent inspection of the helicopter could find no apparent mechanical faults which may have caused the engine to stop. It also revealed an absence of fuel in the fuel tanks and in the remainder of the fuel system.

Fuel capacity

The FAA (Federal Aviation Administration of the USA) approved Flight Manual produced by the helicopter manufacturer for the F-28A states in its description of the fuel system that the helicopter is fitted with two fuel tanks, each with a capacity of 15 US gallons. The Manual makes no mention of an unusable fuel quantity, but it does state that the mixture control should be pushed in (the fully rich position) during all flight operations. In the weight and balance section the Manual indicates that 30 US gallons of fuel weighs 180 lbs.

Performance data

The '*Performance Data*' section of the Flight Manual does not contain any fuel consumption data. The '*F-28A Specifications*' section of the same manual states a specific fuel consumption for the engine of '*0.5lb/hp/hr'* (pounds per horsepower per hour) and a '*normal'* power output of 205 HP. The fuel consumption at this '*normal'* power output equates to 102.5lb/hr, giving a maximum flight duration of one hour and forty-five minutes. There was no data equating horsepower with cruising or climb speeds to support any calculation of typical fuel flow rates.

However, the engine manufacturer's manual for the Lycoming HIO-360-C1A contains a chart comparing fuel flow with percent rated power. This indicates that the fuel consumption is about 72 lb/hr at 65% power and 86 lb/hr at 75% power. The 72lb/hr rate at 65% power equates to a maximum flight duration of two and a half hours.

Helicopter manufacturer's statement

The Enstrom F-28 model aircraft was certified under CAR 6 (not under the Federal Aviation Regulations) and continues to be subject to those recommendations. The Flight Manual for the F-28A was directly approved by the FAA in 1968 and was re-printed in 1972.

The helicopter manufacturer agreed that the only references to fuel consumption in the current revision level of the F-28 Rotorcraft Flight Manual (Revision 10 dated 22 May 1998) was the '*0.5lb/hp/hr'* consumption rate and the total fuel capacity of the tanks. Later model production aircraft have a manifold/fuel pressure gauge marked with pounds per hour along with the fuel pressure scale on the fuel pressure side of the gauge. The same instrument on early production models has only the fuel pressure scale. Moreover, because the unusable quantity of fuel in the F28A is less than 1 US gallons, neither the fuel quantity indicator nor the Flight Manual were required to provide unusable fuel quantity information.

Analysis

The pilot realised he was running low on fuel but the engine stopped when the tanks emptied before he completed the precautionary landing. The only source of fuel consumption data available to him in the Flight Manual was unusable unless all operations were conducted at '*normal'* power. The meaning of '*normal'* in this context is not stated but it is likely to mean the maximum power output at full throttle under ISA conditions for this version of the fuel-injected engine running at 2,900 rpm. Full power may not be appropriate during the cruise but no information is contained in the Manual which would allow any pilot to calculate the expected fuel consumption at the lower power settings experienced during a transit flight.

Slightly more useful fuel consumption information was available in the engine manufacturer's Operator's Manual, but being generic it was of little use without data relating power output to manifold pressure or a combination of weight, temperature and airspeed. Moreover, the pilot did not possess a copy of the engine manual and therefore did not have even this generic information available to him.

The pilot relied for his pre-flight fuel planning on the indicated fuel consumption he had previously witnessed on the helicopter's fuel flow gauge of approximately 55lb/hr in the cruise. Based on the pilot's assumed fuel consumption this would give a maximum flight endurance of three hours and sixteen minutes. The return flight to Nottingham had a total planned flight time of two hours and twenty-four minutes which, if his assumption was correct, would have given a reserve of some fifty-two minutes. Despite the divergence from the planned track, the forced landing took place 65 track miles from Nottingham which was less than the 78 nm distance between the two airports.

Conclusion

The helicopter's engine lost power due to fuel exhaustion. The pilot had departed with what he believed to be sufficient fuel on board based on an incorrectly assumed fuel consumption figure. This belief was reinforced by indications on the helicopter's fuel flow and fuel quantity gauges.

The flight time between the helicopter refuelling and the engine cutting out was approximately two and a half hours. This appears to be the endurance equivalent to cruising at 65% power but the difference between the observed fuel flow of 55 lb/hr and the 72lb/hr predicted at this setting could not readily be explained. Historically, the fuel quantity indications on many light aircraft have proved to be inaccurate. The effect of relying on such indications is, ultimately, that the aircraft might unexpectedly run out of fuel.

Whilst many pilots take precautions against inaccurate quantity gauges by dipping their tanks or by only filling them completely full, they still require accurate fuel consumption figures to be able to determine the expected duration that the fuel on board will allow. This position is potentially made worse by the contrast found in the accuracy of modern car fuel gauges. Not only do most cars now display low fuel contents warnings, but some cars also allow average fuel consumption figures to be displayed. The temptation is for the same level of confidence to mistakenly be transferred by a user to a potentially less accurate helicopter system, with obvious results.

It was surprising that the FAA approved Flight Manual did not contain any suitable information on fuel consumption. Certainly there was no information available that would have allowed the pilot to calculate the fuel requirement for his flight with any level of accuracy. The relationship between fuel pressure and fuel consumption is established on later model production aircraft.

The absence of useful fuel consumption data from the Flight Manual may have been a causal factor in this accident. Therefore, it was recommended to the FAA that:

Safety Recommendation 2005-059

The Federal Aviation Administration of the USA should instruct the Enstrom Helicopter Corporation to include useful information on fuel consumption rates in all their Rotorcraft Flight Manuals.

Response to Safety Recommendation 2005-059

The helicopter manufacturer decided not to act independently upon the safety recommendation because (quote):

> *'in accordance with the applicable regulations under which the aircraft was certified, ie CAR 6.743, Performance Information, fuel consumption rates are not "required" to be included as part of the performance information in the Flight Manual'.*

In March 2000 the manufacturer issued a Service Directive Bulletin (SDB 0092, Fuel Quantity System Calibration) which required annual checking/calibrating of the aircraft's fuel quantity system. Subsequent enquiries by the AAIB revealed that the last time this SDB had been carried out on G-BAAU was on 10 June 2001. There was no record in the aircraft logbooks of it being carried out during any of the subsequent annual inspections. This factor may explain inaccurate fuel quantity indications on G-BAAU.

A response from the recommendation addressee, the FAA, has not yet been received. The FAA's response will be reported in the AAIB's annual review of Safety Recommendations.