Agusta A109E, G-DPPH, 25 December 2001

AAIB Bulletin No: 2/2003	**Ref: EW/G2001/12/14**	**Category: 2.2**
Aircraft Type and Registration:	Agusta A109E, G-DPPH	
No & Type of Engines:	2 Pratt & Whitney W-206C turboshaft engines	
Year of Manufacture:	1999	
Date & Time (UTC):	25 December 2001 at 1520 hrs	
Location:	Cross Hands, Wales	
Type of Flight:	Public Transport (Passenger)	
Persons on Board:	Crew - 1	Passengers - 2
Injuries:	Crew - 1 (Minor)	Passengers - 1 (Minor)
Nature of Damage:	Severe damage to: tail cone; main and tail rotor blades; and landing gear	
Commander's Licence:	Airline Transport Pilots Licence (Helicopters)	
Commander's Age:	40 years	
Commander's Flying Experience:	4,294 hours (of which 440 were on type)	
	Last 90 days - 51 hours	
	Last 28 days - 12 hours	
Information Source:	AAIB Field Investigation	

Summary

The aircraft was returning from Morriston Hospital, Swansea to the operators base near Carmarthen with a pilot and two passengers onboard when it suffered a double engine failure due to fuel starvation at height of approximately 400 feet above ground level (agl).

Background to the flight

On Sunday 23 December 2001 the helicopter was flown on a short local flight from its operating base, during which the left, forward fuel tank, electric booster pump failed. The pilot established from the locally produced Minimum Equipment List (MEL) that flight was permitted with one electric fuel pump inoperative provided that the cross feed system was operative and the Rotorcraft

Flight Manual (RFM) limitations were observed. The MEL did not specify what the RFM limitations were nor did it cross-refer the reader to the appropriate page in the RFM.

Having consulted with the maintenance organisation, the pilot entered the defective pump on the daily record page and on the deferred defect control sheet of the aircraft technical log in accordance with the requirements. He also contacted the pilot who was scheduled to fly the aircraft the following day in order to brief him on the defective pump and the action taken. The maintenance organisation intended to replace the pump on Wednesday 26 December and had requested the operator to have minimum fuel in the tank, which would have to be drained in order to change the pump.

On Monday 24 December the duty pilot, having confirmed from the aircraft technical log that the electric fuel pump was still unserviceable, identified in the locally produced Emergency Checklist the appropriate failure on page 43, headed Failure of Fuel Pump 1 (2). Three indications were listed which were: FUEL PUMP 1 caution message displayed on Electronic Display Unit (EDU) 1 together with fall in fuel pressure of the affected system; XFEED advisory message displayed on EDU 2; and to check that the cross feed valve had opened automatically and fuel pressure on the affected system had increased. The Actions: required by the Checklist were to check if the No 1 airframe fuel filter, A/F F FLTR caution message was displayed. Only if that caution was displayed did the pilot need to go to page 44 and carry out the Failure of fuel pump 1 (2) and airframe fuel filter 1 (2) partially clogged procedure. Since the filter partially clogged condition was not present, only page 43 was applicable. The second action was manually to select the cross feed switch to CLOSED because with the switch on the NORMAL position, the cross feed valve should open automatically when a pump failure is sensed in order to maintain boosted fuel pressure to both engines. The checklist then stated, proceed with flight with engine 1(2) in suction mode. The final item on page 43 was a caution which stated.

CAUTION

The unusable fuel, in the forward lower tank with the failed fuel pump, increases from 4 kg to 20 kg.

History of the accident flight

The helicopter was not flown on 24 December. When the same pilot commenced duty on Tuesday 25 December, he carried out the normal pre-flight duties and inspections but did not consult the emergency checklist, having done so the day before. The total fuel on board the aircraft was 340 kg of which 150 kg were used during a one hour flight in the late morning. The aircraft would normally have been refuelled to the standard operating fuel load of 400 kg but, given the request for minimum fuel for the pump change, a fuel remaining weight of 190 kg was considered acceptable because more fuel could have been loaded if the next task had required it.

That afternoon the aircraft was tasked to move a patient from a nearby landing site to Morriston hospital. The pilot estimated that the total flight time would be 30 minutes and with an hourly fuel burn rate for planning purposes of 200 kg, the 190 kg of fuel remaining was adequate. Flight time to the site was 18 minutes and the helicopter departed the site for the hospital with 143 kg remaining arriving 6 minutes later. Having shut down and offloaded the patient, the aircraft lifted off with 115 kg of fuel for the 10 minute flight back to the operating base. Given the caution of increased unusable fuel of 20 kg contained on page 43 of the Emergency Checklist, and the

estimated fuel required of 40 kg for the short transit back to base, the pilot considered that adequate fuel was available.

Shortly after departing the hospital, the aircraft encountered a line of heavy snow showers across the track to the operating base. The pilot established that the snow had passed over their destination, which was reported as being in sunshine. He explained to the two passengers that 96 kg of fuel remained which he calculated was enough for 30 minutes of flight at reduced power. Their base at that point was about four minutes flight away at the normal cruise speed of 130 KIAS. The pilot informed his passengers that he intended to fly through the band of snow provided that adequate visibility could be maintained. He descended the aircraft to a height of 400 feet agl and reduced the airspeed to 80 KIAS in order to retain good visual contact with his main reference feature, which was a dual carriageway.

After the aircraft entered the snow shower, the FUEL PUMP 2 caption on the EDU began to flicker and then remained on. The pilot considered that the No 2 fuel booster pump had also failed and informed the passengers that they would continue the short distance to the operating base. He explained that the engine driven pumps had sufficient suction to draw fuel from the tanks and thereby maintain an adequate fuel supply to the engines. A few seconds later both engines ran down and the rotor RPM decayed. The pilot realised he had suffered a double engine failure and lowered the collective pitch lever in order to try and restore the rotor RPM. He warned the passengers that they would make an emergency landing and saw a clear field ahead, selected the landing gear down and started to transmit a MAYDAY distress call. Near the ground he flared the aircraft and raised the collective pitch lever in order to cushion the touchdown but this appeared to have little effect. The aircraft landed heavily with low forward speed but with a high rate of descent. It remained upright, the tail boom having detached and the main and tail rotor blades suffered major damage.

Safety and survival

The pilot had transmitted a brief MAYDAY distress call which was received by London Flight Information Service who notified the Aeronautical Rescue Co-ordination Centre (ARCC). The Air Observer in the aft cabin seated at the operators console also transmitted on the operational radio frequency that the aircraft was going down at Cross Hands. That message was received by the control room operator, who activated the Emergency Services response to that location. After landing, all three occupants vacated the helicopter through the normal exits and the pilot contacted the control room by mobile telephone to inform them that they were safe. The emergency services arrived at the scene 12 minutes after the accident.

Everyone on the aircraft was wearing a flying helmet. Both the pilot and the front seat passenger struck some part of the aircraft with their helmets despite wearing four-point inertia real harnesses. Both helmets were sufficiently damaged for the manufacturers agent to declare them unfit for further use.

The aircraft fuel system

The aircrafts fuel system consisted of an extended range tank with a capacity of 80 kg, which delivered fuel under gravity to the aft main fuel tank with 256 kg capacity. The aft main tank supplied two forward fuel tanks (left and right), each containing 110 kg of fuel, each of which in turn supplied its respective engine. The fuel was transferred to collector tanks within the forward fuel tanks by a combination of gravity and jet pump units, which ensured that they were kept full.

Each collector tank contained an electric fuel booster pump, which raised fuel under pressure to the respective engines fuel control system. Each engine also had a mechanical engine-driven pump that was capable of raising fuel from its associated forward tank by suction. A cross feed line interconnected the fuel supply lines from the forward tanks to their respective engines. A diagram *(jpg 29kb)* of the fuel control panel is shown below.

If an electric booster pump fails with the cross feed switch in the NORMAL position, the cross feed valve opens automatically. It can also be manually selected to OPEN or CLOSED by use of the cross feed selector switch. The cross feed valve open condition permits one booster pump to supply fuel to both engines from one forward tank. The cross feed closed condition allows one engine to be supplied by a serviceable booster pump and the other to draw fuel by suction provided that there is no restriction or blockage in the fuel feed pipe. Fuel pressure, pump status and cross feed open condition were displayed on the EDUs.

Analysis

The MEL was deficient in that it simply stated the aircraft could be despatched with an inoperative fuel pump provided the cross feed system was operative and the Flight Manual Limitations were observed. It did not re-iterate those limitations nor did it give pilots guidance on the significance of the cross feed valve position. By default, pilots had to turn to the emergency checklist for advice on the despatch procedure, a purpose for which the emergency checklist was not intended.

The Emergency Checklist available to the pilot was reproduced from that contained in the RFM and was of the flip card type. The pilot had read page 43 of the Emergency Checklist on Monday and confirmed that there was no A/F F FLTR caution message displayed; therefore, the information contained on page 44 was not relevant to the failed electric fuel pump. He had not revisited the Emergency Checklist before flying on the Tuesday but he believed that fuel in the forward left tank was available, subject to the increased unusable figure of 20 kg, and that the mechanical engine driven pump was capable of drawing fuel from that tank.

An important action required with a failed fuel pump, was to close the cross feed which opened automatically. This ensured that each engine drew fuel from its respective forward tank. However, in this accident, with the cross feed open, the functioning booster pump effectively pressurised the cross feed line, preventing fuel from being sucked from the left forward tank by the left engine driven pump.

In the case of a failed fuel pump and airframe fuel filter partially blocked on page 44, the fuel cross feed remains open in order to maintain a flow of pressurised fuel to both engines. The only action stated was to proceed with flight. There was, however, an important caution message which accompanied that action which was relevant to the configuration of G-DPPH with the cross feed open. This was:

CAUTION

The fuel in the forward lower tank with the failed pump (maximum of 105 kg) cannot be used when flying with the crossfeed valve open.

The position of the cross feed valve was indicated by a horizontal flag on the fuel control panel. The pilot could not recall why he had not closed the cross feed valve but not having seen the CAUTION on page 44, he believed that he still had sufficient fuel in the forward left tank to

continue the short distance to his operating base. A FUEL LOW warning light would have illuminated when 35 kg of fuel remained in the forward right fuel tank from which fuel for both engines was being drawn. It is probable that the FUEL LOW warning was displayed during the start sequence but it would have been accompanied by other warnings that also activate the master caution light. A button on the collective pitch lever cancelled the master caution light. This button was activated by the pilot during the start sequence and he could not recall seeing the FUEL LOW warning light. However, the warning light would have remained illuminated for the remainder of the flight. His attention was drawn to the illumination of the master caution light and the FUEL PUMP 2 caution message when no useable fuel remained in the right tank.

Check list

The check list used by the pilot was produced by the operator in flip card format. The Emergency Drills section of the flip cards was compiled from the relevant pages of the Emergency and Malfunction procedures within the RFM produced by Agusta. Those pages were endorsed with either E.N.A.C Approved on behalf of CAA or RAI Approved on behalf of CAA. (ENAC is the abbreviated form of Ente Nazionale per lAviazione Civile the Italian Civil Aviation Authority. RAI is the abbreviated form of Registro Aeronautico Italiano).

Both the operators checklist and the RFM contained procedures for continued flight after a fuel pump failure, both with and without an accompanying fuel filter partially clogged caveat. The essential difference between the two drills was the cross feed valve position and its impact on the quantity of unusable fuel.

The RFM version of the Failure of Fuel Pump 1 (2) listed the indications and actions on one page which appeared to end with the statement Proceed with flight with engine 1 (2) in suction mode at the bottom of the page. However, this was not the whole drill since the associated CAUTION message was on the next page. The operators checklist did not suffer from this unreferenced continuation onto the next page.

The RFM Section entitled Emergency and Malfunction Procedures listed the EDU message FUEL PUMP 1(2) as being one of several caution messages (yellow) and outlined but did not itemise the corrective action for each message. Associated with this reference to FUEL PUMP 1(2) failure was a CAUTION on page 3-10 which stated Take care that the fuel contained in one of the forward lower tanks (at maximum about 110 kg) cannot be used when flying with the crossfeed valve open. However, this caution was not repeated within the itemised Failure of Fuel Pump 1(2) procedure on page 3-55A.

Since the pilots did not routinely use the RFM in flight, this was not a factor in this accident. However, the operators Emergency Drills checklist carried forward this system of duplicate (but significantly different) entries for fuel pump failure. The 110 kg caution was included on page 25 which described the significance of EDU messages and listed the corrective action for FUEL PUMP 1(2) failure as Affected fuel pump OFF. But the itemised drill on page 43 did not contain this cautionary warning. Its associated caution about the increase in unusable fuel from 4 kg to 20 kg was only valid if the pilot had followed the complete itemised drill and had closed the crossfeed valve.

Conclusions

The investigation concluded that the accident occurred because of a double engine run-down due to fuel starvation. The factors that had contributed to that situation were:

1.The aircraft was being operated with the fuel on board being kept to a minimum in order to facilitate the fuel pump change.

2.The information contained in the CAUTION that, with the cross feed open, fuel in the tank with the failed pump was not available, was not contained in the RFM or locally produced Emergency Checklist itemised drills for fuel pump failure.

3.The CAUTION that, with the cross feed open, fuel in the tank with the failed pump was not useable, was listed in the RFM and locally produced Emergency Checklist in sections relating to the meaning of EDU warning and caution messages.

4.Over 24 hours had elapsed since the pilot had consulted the Emergency Checklist and this may have contributed to his not having closed the fuel cross feed.

5.The locally produced MEL did not explain or refer the reader to the significance of the cross feed valve position.

It was also noted that those on board were equipped with full safety clothing and the wearing of flying helmets had contributed to the fact that no significant injuries were suffered by any of the occupants.

Safety Recommendations

Had the MEL included the procedure to be adopted before flight, the pilot could have read it before departure and not needed to consult the checklist. However, the layout of the RFM check list was unsatisfactory in that the completion of each procedure was not clearly indicated and important caution messages might be overlooked by an operators staff when preparing their emergency drills checklist from the RFM.

Since a failure of one pump automatically opens the cross feed valve, the caution message Take care that the fuel contained in the forward lower tank with the failed pump (at maximum about 110 kg) cannot be used when flying with the crossfeed valve open should be repeated in the itemised Failure of fuel pump 1 (2) procedure. A second reason for adding this caution to that procedure is related to the MEL. Because the helicopter can be dispatched with the cross feed valve system inoperative, subsequent failure of a fuel pump or clogging of an airframe fuel filter could have a major impact on the aircrafts range and endurance, depending on the failed (fixed) position of the cross feed valve. Therefore, the following safety recommendations were made:

Safety Recommendation 2002-36

The UK Civil Aviation Authority should require helicopter AOC holders Minimum Equipment Lists to state the relevant actions and procedures for dispatching an aircraft with any unserviceable item which may have a significant impact on subsequent safe operation of the aircraft.

Safety Recommendation 2002-37

The UK Civil Aviation Authority, in conjunction with the Italian Ente Nazionale per lAviazione Civile, should revise the layout of the Agusta 109 Rotorcraft Flight Manual Emergency and Malfunction Procedures pages so that:

a. The caution message contained in the Failure of fuel pump 1(2) reference on page 3-10 of the Rotorcraft Flight Manual is repeated in the itemised Failure of fuel pump 1 (2) drill on pages 3-55 A and 3-55B of the Rotorcraft Flight Manual.

b.Either the continuation of any drill onto the next page should be clearly indicated or the completion of each drill should be clearly indicated.