Hughes 369E, G-SIVA

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Aircraft Type and Registration:	Hughes 369E, G-SIVA
No & Type of Engines:	1 Allison 250-C20B turboshaft engine
Year of Manufacture:	1989
Date & Time (UTC):	21 August 2000 at 0930 hrs
Location:	Dartford Marshes, Kent
Type of Flight:	Private
Persons on Board:	Crew - 1 - Passengers - 1
Injuries:	Crew - 1 (Serious) - Passengers - 1 (Serious)
Nature of Damage:	Aircraft destroyed
Commander's Licence:	Private Pilot's Licence (Helicopters)
Commander's Age:	55 years
Commander's Flying Experience:	938 hours (of which 65 were on type)
	Last 90 days - 15 hours
	Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and examination of the failed air signal pipe by the AAIB and DERA

History of the flight

The aircraft took off from a private helipad in Kent. When passing north of Dartford at 1,500 feet, without prior warning, there was a sudden loss of engine power. The pilot established an autorotative descent and transmitted a 'MAYDAY' call. He does not recall hearing the 'Low Rotor RPM' warning at any time and noted that the rotor RPM stabilised at the correct autorotation speed. The rate of descent was about 2,000 feet/min and the engine-off landing was heavy. Both occupants received serious injuries but the aircraft remained upright and there was no fire. The impact splayed the landing skids and crushed the underside of the fuselage, rupturing the fuel tanks. The engine on this type is mounted in the aft fuselage at an angle of 45û and the engine bay doors and combustion casing were crushed in the impact.

The Thames Radar controller heard the "MAYDAY" call and the response to his request for the number of souls on board was, "Standby". No further call was received from the aircraft. No transponder response had been received from the aircraft but a primary radar return had been seen near Dartford and this position was confirmed by the pilot before the emergency developed. Valuable assistance in locating the helicopter was provided by the crews of two light aircraft and it was located at about 0935 hrs. The police, fire and ambulance services were quickly on the scene. A helicopter air ambulance arrived at 0950 hrs and the crew attended to the occupants, who were then taken by road to a nearby hospital which had accident and emergency facilities. The pilot reports that his survival would have been unlikely without this prompt emergency response.

On site examination

An insurance surveyor inspected the aircraft on site and observed that one of the engine's air signalling pipes was broken. He photographed the pipe in situ and subsequently supplied it to the AAIB for metallurgical examination, which was carried out at DERA Farnborough. The pipe in question (Part No 6870035) conveys compressor outlet pressure (Pc) to the Fuel Control Unit (FCU). A pressure signal is taken from the compressor delivery position and piped to the Power Turbine Governor (PTG). A tee-piece at the PTG inlet allows the signal to be routed on to the FCU. The subject pipe, from the tee-piece to the FCU is, in form, a wide 'U' shape; the exit portion from the tee-piece and the entry to the FCU are approximately parallel (Figure 1). An anti-vibration support (P-clip) is prescribed part way along the pipe and this was correctly in place. At each end the pipe is secured by a 'B' nut which clamps the flared end of the pipe to the male part of the union. There is an integral flared sleeve within the nut, which provides the clamping surface and also projects by 4 mm beyond the outer end of the nut and is a close fit around the pipe at its entry to the nut.

Detailed examination of the failed air signalling pipe

The pipe from G-SIVA had broken adjacent to the FCU, about 4 mm from the flared end and at a position which was inside the 'B' nut's integral sleeve (Figure 2). Metallurgical examination showed that the circumferential fracture had progressed almost entirely in fatigue. From a single origin, the crack had developed more quickly in one direction than the other and its path was slightly helical. The faster crack had developed almost around the full circumference until it overlapped the slower crack and an intercepting fracture developed between the two to allow final separation. The single origin identified was on the pipe's outer surface, positioned at about 45û to the plane of bending of the pipe and on the outside relative to the nearest bend.

The liberated part of the pipe had contacted the inner surface of the sleeve producing some fretting damage and a witness mark matching the fractured end of the pipe. On the end of the pipe held by the 'B' nut there was also some fretting evident around the area of the fatigue origin but detailed examination showed that the area also contained numerous corrosion pits, some of which were outside, though adjacent to, the areas of fretting. The DERA metallurgist considered that pitting was a more pernicious condition in terms of fatigue crack initiation than fretting and was, therefore more likely to have been the initiator. A metallographic section through the pipe near the origin showed a pit close to the origin but the origin itself was obscured by damage and there was also fretting in this area.

The DERA metallurgist considered the pitting to be due to anaerobic (crevice) corrosion which can occur in stainless steels where access to oxygen is limited. No corrodant was identified but it is feasible that crevice corrosion can occur in the presence of atmospheric moisture, acting as an electrolyte, retained by capillary action. The main requirement is the setting up of an oxygen differential cell at a favourable site on the steel surface and such a site could result from the loss of the steel's oxide layer due to fretting. The other end of the pipe, near to the PTG connector, was also examined and a similar condition found in terms of fretting and pitting. In the pitted region a small trace of aluminium was found which could have contributed to the creation of electrolytic cells on the surface.

The material's hardness and microstructure were consistent with the specified stainless steel (AISI 321) but the DERA metallurgist observed that this type of steel is not resistant to crevice corrosion and a stainless steel containing molybdenum or one of the higher chromium steels might be more appropriate.

The engine manufacturer disagreed with the identification of crevice corrosion as a process involved in this failure and identified fretting as being, in their experience, the common and predominant feature, the fretting being a result of insufficiently accurate alignment of the pipe on assembly. The Model 250-C20 Operation and Maintenance Manual contains extensive and precise instructions on the proper installation of such pipes to achieve accurate alignment. An Alert Customer Service Letter A-1166 also applies and red warning tags are attached to all replacement components supplied to warn the installer of the need for correct installation.

Maintenance

The company that had carried out most of the maintenance on the aircraft since it had been imported reported that there had been recurrent reports of low engine power. These had been addressed by rectifying leaks in the anti-ice or bleed air systems but power had only been recovered to the minimum specified. The subject air signal pipe had been disturbed on six occasions since July 1997. In October 1999 the FCU was modified in accordance with CEB A-1329 and FAA AD 98-24-28 (replacement of bellows assembly). Thereafter, the engine suffered stagnation during starting and extensive investigations were carried out, including leak checks of the pipework and replacement of the FCU. The problem appeared to be solved by the final FCU change, although the engine still exhibited some "hesitation" during start.

When the broken Pc pipe was first seen it was noted that the end of the pipe was out of alignment with the 'B' nut by about half a pipe diameter i.e. about 3 mm. After it had been photographed in that position it was found that only very light pressure was required to push it back into alignment which it then maintained. Given this and the severity of the impact it is not considered that the observed misalignment can be taken as evidence of any misalignment of the pipe during the last FCU installation. However, the presence of fretting inside the 'B' nut sleeve showed that there had been contact, due either to misalignment at some time or through induced vibration of the pipe. The anti-vibration 'P' clip was in place properly installed on the pipe.

Sources of possible external vibration were considered. A few days before the accident the owner reported high frequency vibration through the rudder pedals. Tail rotor balance was measured at 0.15 ips and was improved to 0.1 ips by adjustment. A small amount of play was also found in one of the tail rotor pitch links. Other pilots considered that although the vibration had been reduced it still remained more than normal. As a possible source of vibration the starter generator was removed and examined. It was run under load as a generator and the balance of its armature was checked. On strip, it was found that both bearing outer races had been skidding and a steel sleeve which houses the drive end bearing in the alloy end-plate was loose. The effects of these defects on the unit's operation could not be determined but no unusual vibration was detected when it was run under electrical load.