No: 2/85	INCIDENT	Ref: EW/C899

Aircraft type and registration:	AS 332L Super Puma G-TIGW (heavy helicopter — public transport)	
Year of Manufacture:	1984	
Date and time (GMT):	14 December 1984 at 0953 hrs	
Location:	14 NM North of Aberdeen Airport	
Type of flight:	Public transport	
Persons on board:	Crew — 2	Passengers — 10
Injuries	Crew — None	Passengers — None
Nature of damage:	None	
Commander's Licence:	Airline Transport Pilot's Licence (Helicopters)	
Commander's Age:	36 years	
Commander's total flying experience:	6942 hours (of which 1843 were on type)	
Information Source:	AIB Field Investigation	

History of the flight

The aircraft was returning to Aberdeen with a crew of two and ten passengers from the Bideford Dolphin (near the Brae Platform) following an out-bound flight which had been entirely without incident. Fuel was not required from the Bideford Dolphin and during its short stay on the oil rig the engines were not shut down. The aircraft took off for the return flight at 0850 hrs and climbed to flight level 40 (OAT 0° to −1°C) where it was flying just above the tops of stratiform cloud. The cruising IAS was 130 kt and oil temperature and pressure indications were normal. At a range of 90 miles on the 059° radial from the Aberdeen VOR the aircraft began to pass in and out of the cloud tops and continued to do so until it reached a range of 45 miles, from which time it was continuously in the top of the cloud layer. During the period when the aircraft was in and out of the cloud tops the co-pilot, a qualified captain on type and who was the handling pilot throughout the return flight, remembered seeing small 'buttons' of clear ice on the windscreen wiper blades. These were no more than 1/4" thick and no greater ice build up was noted on the wiper blades as the flight progressed.

The aircraft continued in cloud, with an OAT of approximately −1°C, along the 059° radial towards the Aberdeen VOR. At 0953 hrs when the aircraft was approximately 10 miles from the Aberdeen VOR, the No 1 engine failed without any prior warning. The crew were alerted by the 'ALARM' and 'DIFF NG' captions and noted that the No 1 NG (gas generator RPM) was passing 15,000 rpm and still decreasing. The co-pilot reduced collective pitch to between 13° and 14° and the commander transmitted a PAN call requesting a priority landing at Aberdeen. The commander had also looked briefly at the icing probe and noted that there was a substantial build up of white rime ice on the leading edge of the probe to a depth of just over half of the radius of the black ring of the disc. There was also white rime ice on the leading edge of the disc. He considered that the build up of ice had been rapid, but at no time during the flight did the 'ICE D' caption illuminate.

The radar controller cleared the aircraft to descend to 3000 feet and gave vectors to intercept the ILS. The crew carried out the shut down drill for No 1 engine, disengaged the height hold, and initiated a descent. They were just about to confirm their actions with the check list when the No 2 engine failed, also without any unusual indications. The co-pilot became aware of a sudden change in noise and lowered the collective lever to establish autorotation.

The governed rotor RPM range is 245—275, with a nominal RPM of 265. The low rotor RPM audio warning is triggered as the RPM drops below 245 and if it falls below 220 both of the alternators, which are driven directly by the main rotor gearbox, electrically disconnect automatically. After the failure of the second engine the audio warning sounded and the RPM was seen at approximately 220. The crew later noted that the area navigation equipment was showing that a power interrupt had occurred and also that the auto-pilot had to be re-engaged, thus it was evident that the rotor RPM had momentarily fallen below 220.

The co-pilot established autorotation at 60 to 70 kt and turned the aircraft into wind. At 0956 hrs the commander transmitted a MAYDAY message which was immediately acknowledged by the radar controller who also passed them the airfield QFE, the surface wind at Aberdeen, and a little while later informed them that their position was near Tarves. By now the aircraft had established a steady rate of descent of 2200 feet per min. The commander carried out the shut-down drill for the No 2 engine, lowered the landing gear, put the brakes on, engaged the nose wheel lock and broadcast "Brace Brace Brace" to the passengers over the PA system.

At approximately 2000 feet the co-pilot had his first sight of the ground and he called for an attempt to re-light the No 1 engine. The commander carried out the start actions but the engine appeared to him to be accelerating very slowly. He therefore allowed the start sequence to continue and initiated the No 2 engine start sequence. This engine appeared to start more readily and, because of the urgency of the situation, he overrode the start sequence by advancing the No 2 Speed Select Lever (SSL). The No 2 engine T4 rose rapidly to 800°C and he retarded the SSL sufficiently to contain the rise in T4 before re-advancing it fully. He called to the co-pilot that 'power was available' and as the No 1 engine had now completed its start cycle he rapidly advanced that SSL also.

The co-pilot had by this time positioned the aircraft for an autorotative landing into a field and was about to initiate the flare when the commander called that power was available. He was therefore able to apply power without flaring and the aircraft climbed away from a minimum height of 200 feet AGL. At 0957 hrs., when the aircraft was some eight miles north of Aberdeen airport, the crew informed ATC that they had relit the engines. The aircraft was cleared for a visual approach to the airfield and landed without further incident.

Technical Examination

As no damage had apparently been caused to the aircraft as a result of this incident, the AIB investigation concentrated on functional and performance testing of, initially, the airframe systems and subsequently the engines.

Fuel System

Examination of the fuel system showed it to contain a total of 1450 lbs of fuel, distributed amongst the seven underfloor tanks. Performance checks on the boost pumps and transfer pump showed all to perform satisfactorily. Rigging and operation of the low pressure fuel cocks also proved to be correct. Visual examination of the interior of the left and right engine feeder (longitudinal) tanks, which contain the boost pumps, revealed the condition of the rubber flap valves, fitted over the end of each transfer pipe at the top of each tank, to be incorrect. That in the left tank had been sucked into the pipe and offered a restriction to fuel being transferred, whilst the support ring around the rubber flap of the right tank had been dislodged. However, these defects were not likely to have had a major effect on the transfer of fuel into the longitudinal tanks as each has a check valve fitted in the bottom of the tank which allows fuel to transfer under the effect of gravity.

Fuel samples were taken from all the aircraft tanks and sent for analysis, the results from which revealed no major abnormalities. A slight trace of free water was present in one tank but not in sufficient quantity that was likely to affect engine operation.

Examination of each fuel filter and ice trap showed only minor quantities of debris, which was judged typical of that to be found in in-service helicopters by maintenance personnel.

Instruments

Engine related instruments including the relevant parts of the failure warning panel, the OAT gauge, pilot static system and main rotor RPM gauge were calibrated on the helicopter. Where appropriate, false signals were injected into the wiring harnesses and compared with instrument readings. Throughout these tests, no inaccuracies were detected. All wiring harnesses between the engine and cockpit were checked for continuity and condition, again with no defects being revealed. The "Leigh" ice detector, fitted to the helicopter to detect the onset of rotor blade icing, was electrically checked and also found to be satisfactory.

Engine Examination

External and, as far as possible, internal visual examination of the engines were conducted with no significant abnormalities being detected. Signs of surface corrosion staining were present on some compressor blades but as these engines had not been washed after flight (as is customary after offshore operations) this was not considered unusual.

The fuel and oil filters were removed and examined and samples of fluid taken for analysis. No abnormalities were found as a result.

Rigging checks of the SSL's to the fuel control units on each engine were carried out. This revealed a difference between the engines, but both were within the tolerance bands specified by the engine manufacturer.

Engine Testing

Following the above examination, functional checks of the engines were carried out. The helicopter was ballasted to a high weight and flown in the hover in ground effect, using firstly No 1 engine and then No 2. Throughout these tests, including the start up and shut down sequences, only one abnormality was recorded. Whilst in the hover on No 2 engine it became apparent that maximum expected power (indicated by maximum rotational speed of the gas generator, Ng) could not quite be obtained, whilst that which was achieved was unstable.

After shutdown, it was confirmed that the hot oil engine intake anti-icing system had been functioning correctly.

During the investigation, the possibility was examined that the double engine flame out may have been caused by ice/slush ingestion. As no visible damage or deformation could be seen on the compressor blades, apart from a small degree of leading edge erosion, it was decided to remove the engines and transfer them to the manufacturer's test facility. Accordingly, the engines were installed on test benches, complete with their respective engine control units (an airframe mounted electronic box), and tested in accordance with the normal production engine test schedule.

The results from this were compared with data measured when the engines were new, which showed both engines to be producing approximately 10 kw less power than at that time, but both were well above the minimum guaranteed power output of 1350 kw. This level of power loss is typical, according to the manufacturer, of engines with total running times of approximately 350 hours and was not considered in this case to be due to any mechanical deformation of the compressor or turbine blades.

Throughout these tests and hover checks, both engines started and ran smoothly without hesitation, but no reason was established to explain the instability of maximum power output of No 2 engine whilst in the hover.

The helicopter has since been returned to service with two replacement engines and is reported as performing normally.

Other factors

During the investigation the possibility was also examined that the double flame out might have been caused by one of three different external factors: contamination of the airframe; the effects of the efflux of the Peterhead power station; the effects of microwave radiation from the Buchan radar site.

Three aircraft of another operator had returned on the same day with contamination of their external surfaces. Analysis of samples showed that the substance was drilling fluid as used on oil rigs. It is not known how these aircraft became contaminated but no trace of the substance was found on G-TIGW, the most recent addition to the fleet, whose external paint was clean.

Although the aircraft flew overhead Peterhead, it is considered that the south easterly wind would have carried the efflux of the power station well clear of the track of the aircraft which was at flight level 40 at this point. In any event, the flame out of No 1 engine did not occur until the aircraft was at least nine miles south west of Peterhead.

At no time did the aircraft enter the high intensity radio transmission zone at Buchan (0.65 miles radius up to 4000 feet), furthermore the aircraft was at least seven miles from the site when the No 1 engine failed.

Meteorological Information

The Meteorological Office made a detailed analysis of the situation based on satellite photographs, ground observations, and upper air ascents. They concluded that at the place and time of the incident there was 8/8 stratocumulus, base about 2,000 feet, with underlying stratus, base about 1,000 feet. There was a temperature inversion, the base of which was at about 4,100 feet with a temperature of approximately −1°C and the tops of the stratocumulus did not extend much above this height. The upper portion of the stratocumulus layer was therefore below freezing. It was also pointed out that the liquid water content (LWC) is always low near the cloud base and increases with height above the base to a maximum at a level which is often near the cloud tops. In the pertaining circumstances at 4,000 feet with a temperature of −1°C in the stratocumulus the theoretical maximum LWC would be 1.0 to 1.5 g/m^3, however the actual value would be unlikely to have exceeded 1.0 g/m^3 and would probably have been around 0.7 to 0.8 g/m^3. The potential for more severe icing is greater at the higher LWC and therefore near the tops of stratiform cloud and particularly stratocumulus. The Meteorological Office advises that the frequency of encountering LWCs in excess of 0.7 g/m^3 in the temperature range 0°C to −1°C is about 0.2%, which is of the order of 5 hours during the 3 winter months in the Aberdeen area.

Icing Limitations

The following is an extract from the G-TIGW Flight Manual Special Supplement No 10.54 entitled "Flight in Limited Icing Conditions Without Icing Protection":

2.3 **Flight envelope authorized for icing conditions**

a. **Flight envelope athorized for continuous icing conditions**

— Maximum pressure altitude 8000ft
— Minimum outside air temperature .... −6°C
— Maximum severity .... 0.4 g/m^3
— Maximum ice deposit:
without horizontal stablizer deicing system:
— Maximum ice deposit 40 mm (beginning of icing indicator red outer ring) with horizontal stabilizer deicing system in working order.
— no time limit

b. **Flight envelope authorized for intermittent icing conditions**

— Maximum pressure altitude .... 8000 ft
— Minimum outside air temperature .... −10°C
— Maximum severity .... 0.8 g/m^3
— Maximum duration .... 5 minutes
— Conditions: Passage through cloud layers or approach. In such conditions the five minute period can only be resumed if the torque has returned to within 2% of its initial value.
Maximum ice deposit is still limited to 40 mm if the horizontal stabilizer deicing system is not fitted.

G-TIGW was fitted with horizontal stabliser de-icing, which was in a serviceable condition at the time of the incident.

Further Testing

In the absence of a technical explanation for the failures, consideration was given to icing of the engines intake meshes. There was no evidence, in the form of unusual engine indications immediately prior to the failures, to suggest that the airflow through the meshes was being seriously impeded by ice build up. It was therefore suggested that an accumulation of soft ice might have occurred on the inside of the mesh and then detached (as a result of vibration or a small temperature change) in sufficient quantity to cause flame out without damaging the engine.

The circumstances of this incident have been passed to the French constructor and certification authority and further testing of the intakes is in progress. These tests are being monitored by the Civil Aviation Authority Airworthiness Division.