Aviation Safety Investigation Report 199403339

British Aerospace Plc BAe-125-700B

10 November 1994

NOTE: All air safety occurrences reported to the ATSB are categorised and recorded. For a detailed explanation on Category definitions please refer to the ATSB website at www.atsb.gov.au.

Aviation Safety Investigation Report

199403339

The Bureau did not conduct an on scene investigation of this occurrence. The information presented below was obtained from information supplied to the Bureau.

Occurrence Number:	199403339	**Occurrence Type:**	Incident
Location:	Essendon		
State:	VIC	**Inv Category:**	4
Date:	Thursday 10 November 1994		
Time:	1439 hours	**Time Zone**	ESuT
Highest Injury Level:	None		

Aircraft Manufacturer:	British Aerospace Plc		
Aircraft Model:	BAe-125-700B		
Aircraft Registration:	VH-HSS	**Serial Number:**	257169
Type of Operation:	Charter Passenger		
Damage to Aircraft:	Nil		
Departure Point:	Essendon VIC		
Departure Time:	1440 ESuT		
Destination:	Adelaide SA		

Approved for Release: Tuesday, September 17, 1996

When passing through 1,000 feet after take off from Essendon runway 26 a loud bang was heard and the left engine was noted to have failed. Concurrent with the left engine failure the right engine driven hydraulic pump failed. The pilot initiated a return to Essendon. Due to the loss of both hydraulic systems the landing gears were extended using the manual system. The manual system does not have any provision for closing the landing gear doors therefore they remained in the down position and created considerable drag. The aircraft would not maintain height on one engine. Rather than approach and land on the shorter Essendon runways the pilot diverted to Melbourne Airport for a successful asymmetric landing.

Investigation.

1. Overhaul agency investigation.

The left engine was removed and transported to a manufacturer approved overhaul agency for disassembly and investigation. The engine internal rotating and stationary components were found to be severely damaged. Assessment by the overhaul agency suggested that the primary failure was a first or second stage low pressure (LP) turbine blade. It was suggested that liberation of this blade resulted in extensive foreign object damage and imbalance of the rotating assemblies with consequent blade, shroud, disc and impellor distress.

It was determined that at the time of failure the engine had completed 6,858 hours and 4,114 cycles since new. Repairs, during which some turbine blades were replaced, were carried out in August 1989, 2,728 hours and 1604 cycles prior to this failure, and in October 1991 1,300 hours and 807 cycles prior to this failure.

2. Materials Evaluation Facility investigation.

The damaged rotating and stationary components were forwarded to the Civil Aviation Safety Authority's Materials Evaluation Facility (MEF) for further investigation.

This metallurgical evaluation determined that, among other damage:

- a total of 84 1st stage low pressure turbine (LPT) blades had been fractured. The fractures were consistent with the application of excessive stress associated with interference from other turbine module components with the tips and trailing edges of the 1st stage blades while the turbine was operating.

- a total of 84 2nd stage LPT blades had fractured with the application of excessive stress. Unlike the damage to the tips and trailing edges as noted on the 1st stage blades, these 2nd stage blades were damaged on their leading edge and the blade platforms, similarly while the turbine was operating.

- the 2nd stage LPT stator assembly had been extensively damaged. The leading and trailing edges of the nozzle guide vanes had been damaged, and the shroud was fractured.

In analysing the sequence of the failure the MEF considered:

(a) the contact evidence of the aft face of the 2nd stage low pressure turbine stator shroud and the leading edges of the 2nd stage rotor blades,

(b) the contact evidence of the 1st stage low pressure turbine blades with the forward faces of the 2nd stage low pressure turbine stator shroud fracture surfaces,

(c) the deposits of metallic aluminium on the 2nd stage low pressure turbine stator shroud fracture surfaces,

(d) the location and extent of the fracture in the 2nd stage low pressure turbine shroud, and

(e) the mechanism of the fracture in the 2nd stage low pressure turbine stator shroud.

The MEF considered that the fracture of the 2nd stage LPT stator assembly was the first event in the engine failure sequence. Evidence of fatigue cracking was found at locations distributed around the circumference of the shroud. Fatigue cracking had initiated at the outer surface of the stator casing at a location that coincided with a marked change in the geometry of the shroud. Thermal expansion of the nozzle guide vanes with each engine thermal cycle would result in the imposition of alternate bending loads on the stator casing - the combination of vane expansion and restraint of the outer casing at its forward and aft edges would lead to the development of a tensile stress state at the outer surface.

3. Manufacturers investigation.

The manufacturer disagreed with the MEF findings. The manufacturers analysis of the 2nd stage low pressure turbine stator shroud found no evidence of any fatigue propagation anywhere on the fracture surface. Their analysis of the secondary damage to the engine indicated it was consistent with a second stage low pressure turbine failure as evidenced by the associated damage compared to other recorded failures in the fleet. They also advise that there has not been any reported second stage low pressure stator assembly fatigue failures during more than 15 million hours of operation of this engine type.

The manufacturer considered that;

(a) the heavy rub on the leading edges of the 2nd stage low pressure turbine blades was secondary to the impact damage on the leading edges of the blades,

(b) the heavy rub on the aft side of the 2nd stage low pressure turbine stator had a fresh appearance and occurred after the impact damage on the vanes,and

(c) the fatigue zone identified by the MEF was a shear lip with extensive smearing indicating an overload failure.

Based on their own material analysis the manufacturer stated that:

'the second stage low pressure turbine stator outer casing was not the primary failure .. but rather (the primary failure was) an airfoil separation of a second stage low pressure turbine blade'.

and, in relation to an airfoil separation;

'unfortunately the exact cause of the second stage blade separations was not determined. The separation of these blades is believed to be related to the non-discernible grain areas detected in the airfoils of one or more blades'.

The manufacturer used a micro etch technique to examine five random blades from this engine, finding one that had a non-discernible grain area.

The manufacturer has issued a service bulletin requiring the removal from service of a series of blades found to have non-discernible grain areas. The one blade from this engine that was identified as having a non-discernible grain area was from a series that were not listed for removal by the service bulletin.

4. Hydraulic pump failure.

The failed hydraulic pump was removed and sent to an overseas overhaul agency for assessment and repair. Although it was a requirement, the overhaul agency did not supply a report on the cause of the failure.

The aircraft is fitted with two separate hydraulic systems. The fact that the right engine driven hydraulic pump failed at the same time as the left engine failed is considered to be a coincidence.

The certification requirements for this type of aircraft do not address the failure of multiple systems as experienced on this flight. Accordingly an engine failure, coupled with a total hydraulic failure leading to a manual extension of the landing gear, will leave the aircraft with high drag profile and low power that would be beyond the experience of most pilots operating this class of aircraft. The aircraft flight manual did not address this problem, nor was it required to, because the event is well outside the certification requirements, and it is unlikely that flight testing was carried out to establish performance parameters that would lead to flight manual recommendations.

5.Bureau determination.

Based on the data made available to the investigation, the Bureau was unable to positively determine what initiated the failure of this engine. The Bureau is not convinced that an airfoil separation due to non-disccernible grain areas was the primary cause. However, if that was the primary cause, and if the manufacturer's service bulletin is properly addressing the removal from service of discrepant blades, then the incidence of engine failures due to this factor should rapidly decrease.
It should be noted however, that the one blade from this engine that was identified as having a non-discernible grain area, was from a series that were not listed for removal by the service bulletin.

If the failure was due to second stage low pressure turbine stator outer casing fatigue, then it is to be expected that more failures of this type could occur, with more definite evidence of fatigue able to be identified, resulting in a fleet rectification program.