BAe RJ85, OO-DJS, March 2000 at 1550 hrs

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INCIDENT

Aircraft Type and Registration:	BAe RJ85, OO-DJS
No & Type of Engines:	4 Allied Signal/Honeywell LF507-1F turbofan engines
Year of Manufacture:	1996
Date & Time (UTC):	14th March 2000 at 1550 hrs
Location:	London City Airport
Type of Flight:	Public Transport
Persons on Board:	Crew - 4 - Passengers - 55
Injuries:	Crew - Nil - Passengers - Nil
Nature of Damage:	Fire Damage to No. 3 Engine
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	Total flight hours - 4,800
	Last 90 days - 175 hours
	Last 28 days - 53 hours
Information Source:	AAIB Field Investigation

Synopsis

The aircraft was on a scheduled passenger flight from London City Airport to Brussels. Shortly after take off the aircraft experienced high vibration and a fire in the No. 3 (inboard right) engine due to failure of the aft (No. 2) bearing on the high pressure rotor shaft. An internal oil fire caused by overheating of the failed bearing caused a brazed joint on the No. 2 bearing oil scavenge tube to fail, allowing fire to spread to the engine nacelle. The fire was successfully extinguished by the flight crew and the engine was shut down in flight. The aircraft landed safely on the remaining 3 engines with no injuries to passengers or crew.

Two Safety Recommendations were made in the course of this investigation.

History of the flight

The aircraft was on a scheduled flight from London City Airport to Brussels. Weather conditions at London City Airport were dry, with surface winds of 320°/13 kts and visibility in excess of 10km.

Take off was from Runway 28 with a right hand turn and climb to 3,000 feet in accordance with the Standard Instrument Departure procedure. The take off and initial climb were normal. During the continued climb to 3,000 feet, accelerating to 250kt, a vibration was sensed by the flight crew for a period of about two seconds. The vibration recurred after a few seconds, accompanied by a No. 3 engine vibration warning ("ENG VIBS #3") and an engine fire warning bell and caption ("ENG FIRE #3"). Cabin crew and passengers reported seeing flames from the No. 3 engine. The flight crew performed the engine fire drill discharging both fire bottles, which extinguished the fire. A 'MAYDAY' was declared with a request for an immediate return to London City Airport, this being the most expedient option available. An ILS approach was flown to Runway 28 and an uneventful landing was completed on three engines. The flight crew chose not to order an emergency evacuation as the fire had been extinguished. The fire services confirmed that the fire was out and the passengers were disembarked by airstairs.

Flight recorders

The aircraft was fitted with an Allied Signal model PV1954C1 Flight Data Recorder (FDR). A copy of the FDR data was provided to the AAIB by the operator. The data showed that the No. 3 engine parameters were normal during the takeoff and initial climb. Approximately 90 seconds after take off there was a slight increase in the No. 3 engine vibration level. Thirty seconds later the vibration level rapidly increased to 2.8 units, shortly followed by No. 3 engine fire and low oil pressure warnings. The fire warning remained on for approximately 45 seconds, then disappeared coincident with the fire being extinguished. FDR data from previous flights showed the No. 3 engine vibration levels to be within acceptable limits and no adverse trends were seen in any of the other engine parameters.

Engine maintenance history

The engine, serial number LF07433, had completed 2,835 hours and 2,648 cycles since the previous workshop visit in June 1998.

There were no defects recorded in the aircraft Technical Log relevant to the incident. Engine health monitoring data for the No. 3 engine showed the vibration levels, exhaust gas temperature, oil temperature and rate of oil consumption trends to be within accepted limits. The operator's approved engine maintenance programme was closely based on the engine manufacturer's maintenance recommendations.

Preliminary engine inspection

The engine was inspected by the AAIB at the operator's engineering base. It was evident that a fire had occurred on the outside of the high pressure compressor case in the 6 to 8 o'clock position as viewed from aft looking forward. The fire appeared to have originated from a joint in the No. 2 bearing oil scavenge tube assembly (part number 2-303-444-01). It was evident that the joint had failed due to melting of the brazing of the joint. The ends of the tube appeared to be intact and undamaged by heat. Examination of the master magnetic chip detector did not reveal any significant metal deposits.

Engine detailed examination

The engine was returned to the manufacturer's incident investigation department in Phoenix, Arizona for strip and detailed examination.

It was established that the high pressure rotor shaft was seized. On stripping the engine, the No. 2 bearing assembly and air diffuser were found to be severely damaged due to the effects of extreme heat. None of the bearing rollers were recovered and the bearing forward and aft carbon seals and faceplates were destroyed by heat. It was not possible to conduct a metallurgical analysis of the bearing due to the severity of the damage. It was confirmed that the bearing seals had come from a known good batch. The engine oil pump operated satisfactorily when functionally tested. No other significant damage was found during the engine strip.

The No. 2 bearing provides support for the aft end of the HP rotor shaft. The bearing seals are of the carbon type and are pressurised by HP compressor air to maintain an oil-tight seal. The engine manufacturer was of the opinion that the No. 2 bearing had most probably failed as a consequence of leakage of bearing seal pressurisation air past the seal because of a seal failure. This would have allowed the bearing cavity to become pressurised with air, preventing an adequate flow of oil from entering the bearing and causing the bearing to overheat and fail. This could not be confirmed however, due to the extent of the damage to the bearing. Frictional heat from the failed bearing had ignited the oil in the bearing cavity causing an internal oil fire. This caused the brazing in the No. 2 bearing oil scavenge tube joint to melt, allowing the fire to spread to the engine nacelle.

No. 2 bearing failure history

During the previous workshop visit, a series of modifications denoted as the XRP (**X**tended **R**eliability **P**ackage) programme were incorporated on the engine. The modification programme was intended to significantly improve the reliability of the engine and included service bulletins ALF/LF 72-1009, 72-1034 and 72-1037. These service bulletins introduced a redesigned No. 2 bearing assembly, new bearing seals and a bearing heat shield, all of which were aimed at improving the reliability of the bearing assembly by reducing bearing operating temperatures. These modifications were introduced as a result of previous No. 2 bearing failures.

The failure of the No. 2 bearing on engine serial number LF07433 is significant in that it is the first recorded case of a No. 2 bearing failure on a post-XRP modification standard engine.

According to data from the engine manufacturer there were eight previous recorded cases of No. 2 bearing failure which resulted in engine fire warnings.

No. 2 bearing oil scavenge tube

The initial design of the No. 2 bearing scavenge tube was a brazed assembly. It was established that the vendor supplying the scavenge tubes to the engine manufacturer had changed the method of manufacture of the tube from the original brazed assembly to a welded assembly in early 1994. The same scavenge tube is used on the ALF-502R and ALF-502L engines. It is estimated that only 40% of the total population of 1,950 502R, 502L and LF-507 engines have the welded scavenge tube installed. The brazed scavenge tubes are currently being replaced on an attrition basis at engine workshop visit.

Oil pump modification

To preclude the possibility of No. 2 bearing oil fires occuring, a new oil pump has been designed. The pump provides a dedicated oil supply for the No. 2 bearing and it is designed to continue to supply oil to the bearing in the event of a failure which pressurises the bearing cavity with air. In tests where the bearing seals were modified to allow air leakage into the bearing pack to simulate a failure, the pump was demonstrated to be effective in continuing to supply oil to the bearing.

The new oil pump is currently undergoing field evaluation tests with an airline operator. The field evaluation is scheduled to be complete by the end of 2001.

Conclusions

The No. 3 engine vibration and fire were caused by a restriction in the oil supply to the No. 2 bearing, possibly due to pressurisation of the bearing cavity by air due to failure of the bearing carbon seals, although this could not be confirmed. Frictional heat caused the oil in the bearing to ignite and the resulting oil fire caused the brazing on a joint in the No. 2 bearing oil scavenge tube to melt, allowing fire to spread to the engine nacelle. The flight crew were able to extinguish the fire using the engine fire emergency procedure.

The nature of the bearing failure was such that it was not predictable using established engine health monitoring and maintenance practices. This is the first recorded No. 2 bearing failure on a post-XRP modification standard engine, which incorporated improvements to the No. 2 bearing to improve its reliability.

An improved oil pump is currently being trialled and the current design of No. 2 bearing oil scavenge tube has a welded joint replacing the original brazed joint.

It is believed that had the modified oil pump been fitted, it would have prevented the No. 2 bearing oil fire from occuring and installation of the welded scavenge tube would stop any No. 2 bearing fire spreading to the engine nacelle.

Safety Recommendations

In view of this incident and previous No. 2 bearing failures which have resulted in engine fires and in order to protect the aircraft from such a hazard, the following Safety Recommendations are made:-

Recommendation 2001-61

The engine manufacturer should take the necessary actions to ensure that the modified oil pump currently undergoing trials is installed on all affected engines as soon as possible, to preclude the possibility of an oil fire from a No. 2 bearing failure occurring.

Recommendation 2001-62

The engine manufacturer should take the necessary actions to ensure that welded assembly No. 2 bearing scavenge tubes are installed on all affected engines in an expeditious manner so as to preclude the possibility of an oil fire from a No. 2 bearing failure spreading to the engine nacelle and hazarding the aircraft.