INCIDENT

Aircraft Type and Registration:	BAe 146-300, G-JEBB
No & Type of Engines:	4 Lycoming ALF502R-5 turbofan engines
Year of Manufacture:	1991
Date & Time (UTC):	15 February 2006 at 1330 hrs
Location:	Approach to Birmingham International Airport
Type of Flight:	Public Transport (Non revenue)
Persons on Board:	Crew - 3 Passengers - None
Injuries:	Crew - None Passengers - N/A
Nature of Damage:	Ruptured hydraulic accumulator and small hole in fuselage pressure hull
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	35 years
Commander's Flying Experience:	4,500 hours (of which 3,000 were on type) Last 90 days - 82 hours Last 28 days - 28 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and metallurgical examination commissioned by the AAIB

Synopsis

During the approach a loud bang was heard by the aircrew, followed by a loss of the yellow hydraulic system. After the aircraft landed safely a hydraulic accumulator was found to have burst. The failure was subsequently attributed to a material defect in the cylinder wall of the accumulator. No one was injured in the incident. A safety action plan is being put in place by the aircraft manufacturer, in conjunction with the accumulator manufacturer, to check other accumulators which might have similar defects.

History of the flight

The aircraft was on a positioning flight to Birmingham Airport and whilst on final approach and at an altitude of between 100 to 200 ft above ground level, a loud bang was heard by the aircrew. Shortly afterwards a caption for hydraulics illuminated and the commander, who was the handling pilot, noticed an indication that the hydraulic fluid level in the yellow system was falling.

The commander believed that the aircraft had suffered a mechanical failure in either the hydraulic bay or the No 2 engine (in which the engine driven pump for the yellow hydraulic system was located). He told the co-pilot that he intended to continue with the landing

since the aircraft was in landing configuration and the failure had caused only the loss of functionality for half the roll spoilers.

After an uneventful landing and with the aircraft at a safe speed the commander turned both the engine driven pump and the AC pump off to minimise the risk of further damage. There was an engineer on board and he visually checked the No 2 engine for any signs of damage or hydraulic leaks. Whilst no damage was evident to the engineer, the No 2 engine was shut down as a precautionary measure and the aircraft was taxied using three engines. As a result of the failure, the park brake was not available so the aircraft was held using toe brakes prior to the wheels being chocked.

After the shutdown checks were completed it was determined that the yellow system accumulator had burst causing immediate loss of functionality of the yellow hydraulic system. Moreover a metal pin from the accumulator had pierced the fuselage pressure hull.

The burst accumulator (see Figure 1) was removed from the aircraft and sent to the AAIB.

Hydraulic accumulator information

There are two hydraulic accumulators located under the BAe 146 fuselage floor close to the main landing gear installation and inside the pressure hull, and these are fitted so that the hydraulic system can cope with fluctuations in demand. The accumulator consists of a pressure cylinder with a piston inside. On one side of the piston is hydraulic fluid and on the other is nitrogen, nominally at 1,000 psi.

The accumulator was assembled in 2001 and was installed in the aircraft 10 months prior to the incident, during which time the aircraft had made 1,844 landings and accumulated 1,593 flying hours.

The pressure cylinders are machined from solid cylindrical steel bar stock of material specification S98 or similar and have a wall thickness of 2.8 mm. The manufacturer's job card specified fluorescent magnetic particle inspection of the cylinder in both longitudinal and circumferential directions to detect for cracks. The manufacture, surface treatment and crack detection of the cylinder were all subcontracted out by the

Figure 1

Accumulator as removed from the aircraft

accumulator manufacturer to specialist organisations. However, the organisation that manufactured the cylinder has since ceased trading.

Metallurgical examination

The damaged accumulator was subject to a metallurgical examination which resulted in two inclusions being found in the cylinder wall. These inclusions were thin strands of non-metallic material that were present in the bar stock prior to machining and were located on the outer face of the cylinder wall running longitudinally. The longer inclusion (see Figure 2) was 5.7 cm long and was where the cylinder initially burst. This was immediately followed by failure of the cylinder wall at the second inclusion. Both the inclusions had reduced the wall thickness locally by approximately two thirds and the discontinuities in the cylinder wall had subsequently grown as a result of low cycle, high stress fatigue (see Figure 3).

Magnetic crack tests were carried out and revealed no other defects in the cylinder.

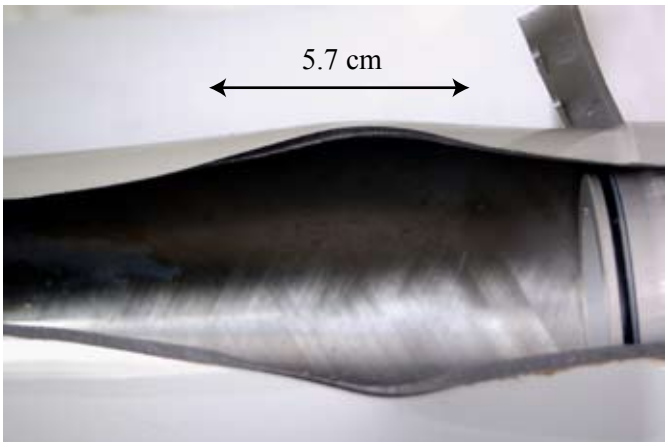

Figure 2

Photograph showing the location of the primary inclusion

Safety action

The manufacturer of the accumulator and the manufacturer of the aircraft were promptly informed of the results of the metallurgical examination. They have examined their inspection records and, at the time of writing this report, are putting in place a programme which includes non-destructive crack detection of those components considered to be at risk. They

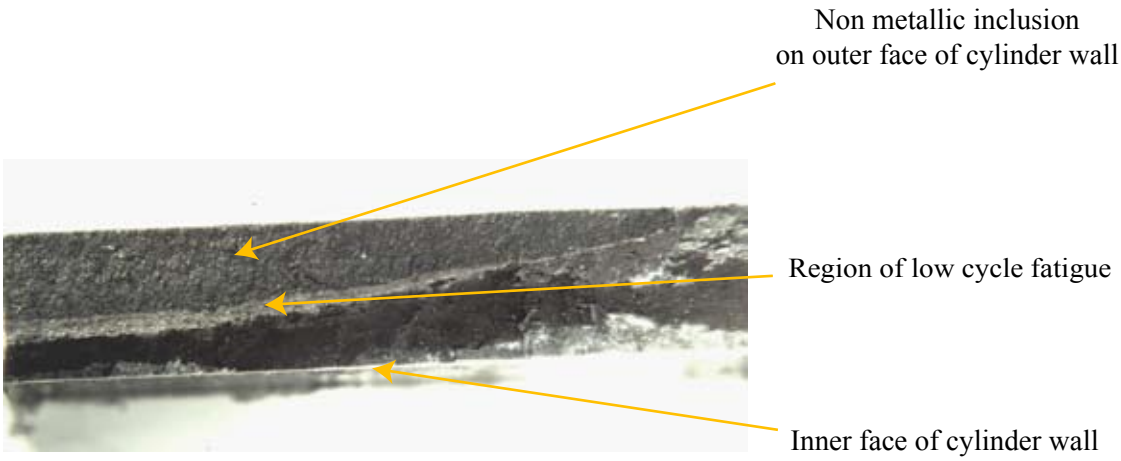

Figure 3

Photograph showing one end of the fracture face for the shorter of the two inclusions

are also reviewing the inspection and manufacturing processes for the accumulators. In view of this it is not considered necessary for the AAIB to make any safety recommendations.

Comment

The failure of the hydraulic pressure accumulator was caused by a pre-existing inclusion of non-metallic material, and this defect progressed through low cycle fatigue resulting in the cylinder bursting.

This type of inclusion in the cylinder can arise if insufficient material is machined away at various stages in the production of the cylinder from the solid steel bar stock. Any defects remaining after machining should have been detected by the subsequent magnetic particle inspection and should have resulted in the cylinder component being rejected.