

BN2B-26 Islander, G-BLDV

AAIB Bulletin No: 2/2000 **Ref: EW/G99/06/27** **Category: 1.2**

Aircraft Type and Registration: BN2B-26 Islander, G-BLDV

No & Type of Engines: 2 Lycoming O-540-E4C5 piston engines

Year of Manufacture: 1984

Date & Time (UTC): 3 June 1999 at 1315 hrs

Location: North Ronaldsay, Orkney Islands

Type of Flight: Public Transport (Passenger)

Persons on Board: Crew - 1 - Passengers - 7

Injuries: Crew - None - Passengers - None

Nature of Damage: Detached cylinder on right hand engine

Commander's Licence: Airline Transport Pilot's Licence

Commander's Age: 58 years

Commander's Flying Experience: 13,000 hours (of which 8,800 were on type)

Last 90 days - 90 hours

Last 28 days - 35 hours

Information Source: Aircraft Accident Report Form submitted by the pilot and metallurgical examination of engine components

Shortly after the commander had selected full power for take off, the aircraft yawed to the right and the right engine RPM was seen to reduce. The take off was abandoned and the engine stopped. After the aircraft was halted the No 3 cylinder (ie the middle cylinder on the right hand side) was found to have become detached from the engine. The piston crown remained within the cylinder, although the gudgeon pin lugs and piston skirt had fragmented.

The engine, cylinder and as much of the metallic debris that could be recovered from the engine bay and from the grass airfield, were returned to the overhaul agency that had overhauled the engine approximately 220 operating hours prior to the incident. The disassembled engine components were examined by the AAIB, with the right hand half of the crankcase, the cylinder, connecting rod and piston fragments being subjected to metallurgical analysis.

It was found that all eight cylinder attachment studs (two of which were 'through-bolts', joining the two crankcase halves) had failed in a high cycle tension fatigue mechanism. A photograph of the

right half of the crankcase is shown at Figure 1. The lower rear stud displayed the least amount of overload on its fracture face and was probably the first to fail. The lower pair of studs had been plastically deformed downwards when the cylinder detached from the crankcase. The failure of the piston gudgeon pin lugs had occurred as a result of a very low cycle (fewer than ten) fatigue mechanism. It is probable that as the cylinder started to detach from the crankcase, the piston became partially jammed in the bore, resulting in excessive loads in the connecting rod and the gudgeon pin lugs.

Two of the cylinder hold-down nuts were recovered, together with the detached portions of the studs. These were fracture-matched to the probable initial stud failure, and to the one immediately above. It was found that the cadmium plating on the thrust faces of the nuts was undamaged, indicating that they had not been torque-tightened onto the cylinder flanges; see Figure 2. Even the chromate passivation film was virtually intact. Several similar nuts from another Lycoming engine were examined, and they clearly showed circular smearing of the cadmium plating. A typical example is shown at Figure 3.

It was clear that grey paint had been applied to the engine after assembly, and some had migrated under at least five of the nuts onto the seats on the cylinder flange. This suggested that the nuts had been loose when the paint was applied.

Additional metallurgical examination conducted on the studs indicated that neither corrosion nor material defect contributed to the failures.

The studs from the Nos 1 and 5 cylinders were removed and crack tested, with none being found. It was therefore apparent that the detachment of the No 3 cylinder may have occurred as a result of at least some of the cylinder hold-down nuts not being torque-tightened onto the flanges. The absence of pre-load in the studs and through-bolts would have resulted in them being subjected to pulsating loads due to the power strokes within the cylinder.

The overhaul organisation's 'final clearance' inspection procedure required a duplicate inspection of the *accessible* cylinder hold down nuts. All the nuts were to be checked in the event of one being loose. The inspection records indicated that this had been done, although it appeared at odds with the evidence of the undamaged cadmium on the nut faces.

The operator's previous experience of broken studs included two occurrences in 1995, each involving a single stud (not a through-bolt) on a front cylinder on engines that had achieved in excess of 2,400 operating hours. All the remaining nuts were found to be correctly torqued. The failures were found to have originated from corrosion in the stud threads; this in turn was attributed to operation in a salt laden atmosphere. The next three occurrences were in the period February to June 1999 and involved single stud or through-bolt failures on the No 1 cylinders of engines that had achieved more than 1300 hours. Again, there was no loss of torque on the remaining nuts and there was no indication, in the form of an oil leak, of an impending failure. Investigation is continuing into these cases. Since 1995, the operator has specified new studs and through-bolts on all overhauled engines.

The subject engine had received no maintenance actions since overhaul, apart from the usual oil and filter changes. No oil leaks had been observed from the No 3 cylinder prior to the failure.