BN2B-26 Islander, G-BLDV

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INCIDENT

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):	18 March 2000 at 2125 hrs
Location:	Overhead Largs, Ayrshire
Type of Flight:	Public Transport
Persons on Board:	Crew - 1 - Passengers - 1
Injuries:	Crew - None - Passengers - None
Nature of Damage:	Right engine crankcase holed; debris and No 1 connecting rod end cap lying in cowling
Commander's Licence:	Airline Transport Pilot's Licence
Commander's Age:	39 years
Commander's Flying Experience:	3,472 hours (of which 531 were on type)
	Last 90 days - 56 hours
	Last 28 days - 6 hours
Information Source:	Aircraft Accident Report Form submitted by the pilot and additional AAIB enquiries

History of flight

The aircraft had taken off from Glasgow on a flight to Campbeltown and had levelled at 3,000 feet. About one minute later, the pilot heard a noise which he described as sounding like hailstones striking the windscreen. However, there was no hail and about one second later the right engine ran down. The right propeller continued to windmill until the pilot successfully completed feathering action. He then transmitted a 'Mayday' call to Prestwick Approach, who offered him the option of returning to Glasgow or a diversion to Prestwick. The pilot decided to return to Glasgow since the weather conditions there were better. The pilot elected not to increase power on the left engine and accepted a gradual descent back to Glasgow where the aircraft later landed without further incident, with the Airfield Fire Service in attendance.

Examination of the right engine

A subsequent inspection of the right engine revealed that the propeller could be rotated although the engine remained stationary. There was a hole in the lower forward face of the crankcase through which it could be seen that a failure of the crankshaft had occurred in the region of the No 1 journal bearing. In addition, the No 4 inlet valve push rod tube was bent, the No 4 cylinder rocker cover was holed and the No 1 piston connecting rod end cap, together with some crankcase debris, was found lying in the lower cowling. Removal of the rocker covers revealed that the No 4 inlet valve spring upper seat had fractured across its diameter, causing loss of valve stem retention and consequent entry of the valve into the cylinder. A similar fracture had occurred in the upper valve spring seat on the No 6 cylinder, but one half of the seat had remained in position and had retained the valve stem.

The engine had accumulated 8,564 hours since new and 1,453 hours since the last overhaul in November 1997. The relevant components of the engine were subjected to a detailed metallurgical examination.

Metallurgical examination of the failed components

The crankshaft had failed at the No 1 connecting rod crank pin. Examination of the fracture surfaces revealed that a fatigue crack had developed across approximately 75% of the crank pin cross section before it had finally failed in overload.

The photograph at Figure 1 shows how the crankshaft fracture was inclined across the pin and passed through the lubrication supply hole. It is probable that this had resulted in a progressive reduction in oil pressure as the crack opened up elastically during the later stages of the fatigue crack progression. In support of this there was evidence of oil starvation, in the form of wear and overheating, on the rocker shafts. The big end bearings also showed evidence of wear resulting from a short period of oil starvation, with white metal (from the bearing insert) having become welded to the No 4 bearing surface.

The crankshaft failure had occurred as a result of long term high cycle tension fatigue. Severe mechanical damage during the final stages of separation had resulted in very high local temperatures being generated and had removed all fractographic evidence at, and adjacent to, the fatigue crack initiation region, which was in the journal radius. The undamaged areas exhibited 'event 'markings, usually considered to represent flight cycles. Forty such marks were clearly visible and it was estimated that at least 150 events would have occurred from crack initiation.

Fluorescent magnetic particle crack detection tests conducted on the crankshaft indicated that pre-existing cracks were also present in the Nos 2 and 3 crank pins (see Figure 2). In addition, the No 2 main bearing was also cracked, in this case as a result of torsional overload that was most probably associated with the crankshaft failure.

Measurement of all the crankshaft journals (ie mains and crankpins) showed that they had been ground 0.006 inches undersize. Microhardness tests were conducted on a sample of material that included the bearing radius in which the crankshaft fracture had initiated. The hardness was found to be low for a nitrided surface, indicating that it had not been renitrided after being ground undersize. (Note: Textron Lycoming Service Bulletin (SB) No 222D, dated 8 November 1999, specified the renitriding requirements for all Lycoming opposed piston aircraft engines. Previously, renitriding was recommended only for crankshafts that were ground or polished 0.010 inches undersize. However SB 222D required all reground crankshafts to be renitrided, although polishing to 0.006 inches undersize was permitted. The reason given for renitriding all reground crankshafts was the non-uniformity of grinding tools. This gives rise to the possibility of a grinding wheel inadvertently removing the nitrided surfaces on one or more of the journal radii, allowing associated stress concentrations to develop in service operation which could develop into fatigue cracks. Lycoming regard SB 222D as 'mandatory', although it has never in fact been officially mandated by either the FAA (Federal Aviation Administration) or the CAA. However the SB was essentially identical to the associated renitriding requirements specified in the engine Overhaul Manual, which had not been amended since 1971).

Thus, although the reason for the fatigue initiation was not fully established, the reduced surface hardness in the failure region of the crank pin radius, coupled with the engine manufacturer's view on the importance of maintaining the hardened nitrided layer, implied that the apparent failure to renitride the crankshaft after grinding could have been a factor.

No metallurgical defects were found on the two failed valve spring seats. Examination of the No 1 connecting rod big end cap and the attachment bolts, recovered from the debris within the engine, found that the bolts had suffered overload failures.

Probable failure sequence

Initial analysis of the evidence indicated a number of possible failure sequences. However it was considered that the most probable sequence of events was that the crankshaft failure had been the initial event, causing the rear part of the engine to be relieved of the propeller loads. The resulting overspeed could then have caused the valve spring seat failures. The inclined faces of the crankshaft fractures had rotated relative to one another, forcing the aft section of the crankshaft in a rearwards direction. The oil pump gear shaft (which is driven by the crankshaft) had also been pushed rearwards, causing the shoulder of the shaft to become friction welded to the pump housing.

On separation of the No 1 end cap, due to its attachment bolts failing in overload as a result of the No 1 crank pin failure, the No 1 connecting rod had remained attached to its associated piston, which then jammed in the No 1 cylinder.

Engine history

The maintenance records showed that the engine had been overhauled in November 1988 at the Lycoming factory in the USA and was then exported to the United Kingdom in December of the same year. Lycoming stated that the engine had a 're-worked crankshaft, Serial Number V2379, Part Number LW-17622.'

The engine was installed on an Islander aircraft early in 1989, and remained with this UK operator. It was removed for overhaul in November 1992, having accumulated 2,394 hours since its previous overhaul in the USA. The engine was then overhauled by a UK company, during which the crankshaft was subjected to non-destructive test (NDT) inspection, but there was no record of the crankshaft serial number. The engine was then released back to service in April 1993.

The engine was installed in another Islander aircraft, where it remained until January 1997 when its next overhaul was due. This was conducted by the same UK company and once again the relevant worksheets contained no record of the crankshaft serial or part numbers. No work was carried out on the crankshaft, other than an NDT inspection. The only significant item of work carried out during this overhaul was a repair to the main bearing bores in the crankcase which was carried out by an engine repair facility in Texas (see later). The engine was then installed on another aircraft in

June 1998. That aircraft became due for a lengthy scheduled maintenance inspection in June 1999, and the subject engine was transferred to G-BLDV.

Whilst it was considered that the repair carried out in Texas may not have been relevant as far as the crankshaft failure was concerned, an attempt to obtain details of that work was unsuccessful. The company replied that the FAA required records to be kept for only two years, and that they had been destroyed. In the UK and Europe, JARs (Joint Aviation Requirements) apply, with JAR 145 covering aircraft maintenance. However, JAR 145.55, which covers the retention of maintenance records, is similar to the FAA requirement in that such records are required to be kept ".... for two years from the date the aircraft or aircraft component to which the work relates was released from the JAR 145 approved maintenance organisation." JAR 145.55 also refers to "Properly executed and retained records", and the necessity to "prove all requirements have been met for issuance of the [certificate of] release to service....." There is no specific requirement to list component part and serial numbers, although this is standard practice in most maintenance organisations. Indeed, the operator of G-BLDV noted that the engine overhaul organisation in the subject investigation had been otherwise meticulous in keeping such records.

Several numbers were visible on the engine crankshaft. One such number, '75040', was electro-etched in the gap between the inserts on the No 1 main bearing; the part number would normally be found in this location. The serial number usually appears on the propeller flange. The numbers and letters found here were: '75038' (stamped), 'WS00022' (vibro-etched) and 'M06MP' (stamped). The last mentioned referred to the fact that the crankshaft was 0.006 inches undersize on Mains and Pins. The letters 'RN' were also stamped on the flange, indicating that a renitriding process had been carried out, notwithstanding the fact that the microhardness tests indicated otherwise. Clearly none of the other numbers bore any resemblance to those with which the engine apparently left the Lycoming factory in 1988. The reason for this was not established. It should be noted that while the possibility exists of accidental exchange of components between two disassembled engines at an overhaul facility, both the original and the substituted crankshafts, if this is what occurred, would have had to have been 0.006 inches undersize on all bearings.

Safety Recommendation

The engine failure occurred as a result of a catastrophic fatigue failure of the crankshaft, which was of uncertain provenance. Engineering records are at the heart of any quality assurance activity but gaps in record keeping are often only exposed during related investigations. In this case, the crankshaft part and serial numbers had not been entered on the inspection records and it could be argued that this did not meet the intent of the relevant JAR, which refers to "properly executed and retained records". However the time required for the retention of such records is only two years. Thus in this investigation the records were not only incomplete, but those that were available need not have been retained beyond two years. Ideally, it would be more useful to retain records for the duration of the overhaul life of the component. The average calendar time between overhauls for the operator of G-BLDV was around four years. It was thus concluded that the mandatory two-year period for the retention of maintenance records is too short and could be usefully extended to five years.

The following Safety Recommendation is therefore made to the CAA in order to address this aspect of JAR 145.55.

Safety Recommendation No 2001-28:

In order that maintenance records may be of enhanced use to post incident and accident investigations, it is recommended that the CAA promote amendment of JAR 145.55 to increase the minimum period for the retention of maintenance records from two to five years.