Piper PA-28-161, G-BJBV

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Aircraft Type and Registration:	Piper PA-28-161, G-BJBV
No & Type of Engines:	1 Lycoming O-320-D3G piston engine
Year of Manufacture:	1981
Date & Time (UTC):	31 May 1996 at 1835 hrs
Location:	Near Shoreham Airfield
Type of Flight:	Training
Persons on Board:	Crew - 2 - Passengers - Nil
Injuries:	Crew - 2 - Passengers - Nil
Nature of Damage:	Damaged beyond economic repair
Commander's Licence:	Commercial Pilots Licence with Instructor and Night Ratings
Commander's Age:	60 years
Commander's Flying Experience:	4200 hours (of which 500 were on type
	Last 90 days - 114 hours
	Last 28 days - 93 hours
Information Source:	AAIB Field Investigation

History of flight

After completing the pre-flight checks, a normal take off wasmade from Runway 25. The initial climb was normal until approximately250 feet when the instructor heard a severe rattling sound fromthe engine area. He immediately started a turn back to the airfieldand transmitted a Mayday message. About 90° into the turnthe engine stopped. Initially the instructor planned to landon Runway 03 but quickly realised that he had insufficient heightto clear some houses between the aircraft and the airfield, andso selected the only field available. The field was small andsurrounded by buildings and fences. The instructor left the finalturn as late as possible and, with full flap, made his final approachinto the field. During the flair he ran out of elevator controlwhich resulted in a heavy landing.

Strip and metallurgical examination

Subsequent strip examination of the engine revealed that the crankshafthad failed at the junction of the centre bearing journal and theforward section of the crank. Metallurgical examination indicatedthat the failure had occurred due to a high cycle tension fatiguemechanism in simple bending across a crank pin. Higher propagatingstresses (and thereby rates) associated with take off had resultedin a series of 'markers' being present in the fracture surfacefrom which the progression of the fracture could be related topropagation per flight ('events'). Many very small progressionbands were present between these take off markers. The widthof each event band varied with flight profiles and the durationof each flight. It was not possible to count the number of eventswithin the initial 0.1 inch of fatigue propagation due to localiseddamage. The number of events counted from this 0.1 inch boundaryto the point of final fracture was between 170 and 180. The surfacelength of the crack corresponding to the first 0.1 inch of propagationwas 0.45 inch. Extrapolation back to the point of the crack initiationat the surface indicated that the total number of events (flights)from crack initiation to final failure was in the order of 1,800.

The broken crankshaft halves were subjected to a magnetic particlecrack detection test and crack indications were obtained in theblend radii between the connecting rod journals and the cranks,in similar locations to the failure but on all the other 'bigend' journals.

Engine overhaul history

The engine was imported, from the USA, in 1989 with 1 hour usedsince it's first overhaul and 2382 hours since manufacturer. In November 1994 the engine, with 1840 hours used since the firstoverhaul, was overhauled a second time. In May 1995, having completed243 flights in 205 hours since the second overhaul, the enginewas removed from the aircraft to which it was fitted because amagneto impulse drive had failed causing pieces of metal to enterthe casing. The engine was overhauled a third time by the sameapproved engine overhaul organisation that carried out the secondoverhaul. In November 1995 the engine was fitted to the accidentaircraft and on the date of the accident the engine had completed176 flights in 97 hours since the third overhaul and 4524hours since manufacture. The evidence from the metallurgicalexamination of the crankshaft failure (*ie* 1,800 flightsto failure) thus indicated that the crack had initiated priorto the second overhaul. Examination of the UK engine log booksdid not reveal any entries to indicate that a propeller strikehad occurred, but an entry in the US engine log book stated thatthe propeller had been replaced, for no specified reason, 34 hoursprior to the first overhaul.

The documentation associated with the 2nd and 3rd overhauls wasexamined. On both occasions the crankshaft had been examinedfor cracks using the magnetic particle crack detection techniquethat is specified in the engine manufacturer's Overhaul Manual. The procedure specified in the Overhaul Manual and the manufacturersService Bulletin No.1285A is the 'Current Flow' techniquewhich will detect cracks running along, and up to 45° to,the longitudinal axis of the crankshaft. It will not detectcracks that are lying in a plane that is 90° 45°to the longitudinal axis of the crankshaft. The *'MagneticFlow'* technique, which is not specified in the Overhaul Manual,is the method required to detect the type of crack that initiatedthis crankshaft failure.

Non-destructive testing provisions

The engine overhaul organisation that carried out the second andthird overhaul was given Joint Aviation Requirement (JAR) 145approval in 1993. A visit by an AAIB Inspector in July 1996 foundthat none of the staff directly involved in Non Destructive Testing(NDT) had undergone any training as specified in paragraph 2 orparagraph 9 of Airworthiness Notice 94, which was issuedby the Civil Aviation Authority (CAA) in November 1990. Two ofthe three individuals who carried

out the NDT inspections of thiscrankshaft during the two overhauls had received NDT trainingas part of their four year apprenticeships with another engineoverhaul organisation in the late 1970's early 80's. One of themhad received a Company Inspection Approval for Fluorescent Penetrant,Dye Penetrant and Ultrasonic Inspection in 1986 and both had passedthe City and Guilds Parts 1 & 2 in Aeronautical EngineeringCraft Studies. They started employment with the overhaul organisationthat carried out the two engine overhauls in 1989 and 1992. Thethird individual, who began employment with the overhaul organisationas a trainee in 1991, had a Letter of Authorisation from thiscompany, dated July 1993, allowing him to conduct Dye PenetrantInspections and Magnetic Particle Inspections of non-ferrous componentswith a note, dated January 1995, that a dual inspection was requiredfor all crankshafts. No records were available to showthat these members of staff had been given any periodic checkson their NDT techniques, or eyesight tests. Assurances were giventhat regular competency checks had been conducted by the QualityControl Engineer, but these did not include eyesight tests**.** The Quality Control Engineer was granted, by the CAA, authorisationin accordance with paragraph 4.3 of Airworthiness Notice 94, issue5, to undertake and certify Magnetic Particle Inspections duringthe period of validity of his Aircraft Maintenance Engineer'sLicence. Neither the signature nor the identification stamp ofthe Quality Control Engineer was entered on any of the documentationassociated with the two engine overhauls.

Paragraph 4.3 of Airworthiness Notice 94, issue 6, dated November1990 states;

CAA approved organisations which have been utilising the servicesof persons not holding a recognised NDT qualification in thesemethods are required to advise the CAA of those named personswhose experience exceeds 12 months for such inspections and whohave a need to continue to practice in these roles (see note). The CAA may be prepared to grant limited authorisation to suchnamed persons based on previous past experience for a period ofnot more than 5 years from the date of this notice.

NOTE: This requirement does not apply in the case of personsqualified in accordance with paragraph 9(a)(ii) of this notice.

9(a)(ii). Personnel holding a current UK Aircraft MaintenanceEngineer's Licence as limited by Airworthiness Notice No 3.

These paragraphs indicated that the Quality Control Engineer'sauthorisation expired in November 1995.

In March and October 1995, and February 1996 the Quality ControlEngineer carried out audit inspections of the NDT Section andin November 1995 the CAA carried out a JAR 145 Audit Inspectionof the overhaul organisation, but no comments regarding staffqualifications, training or records of those involved with NDTinspections were noted.

Since the visit by AAIB in July 1996, the overhaul organisationhas sent two members of it's staff on a recognised NDT course,which they passed at Level 2, and it is proposed to send two othermembers of staff on the same course early in 1997.

Safety Recommendations

As a result of the findings arising from this investigation, thefollowing Safety Recommendations are made:

96-86: FAA should require the manufacturer of Lycomingpiston engines to amend the Magnetic Inspection section of applicableengine Overhaul Manuals to include a procedure which will reliablydetect cracks that lie at 90° 45° to the longitudinalaxis of the crankshaft on such engines

96-87: The Civil Aviation Authority should seek assurancethat the magnetic particle crack detection techniques utilisedwithin the UK aviation industry are fully capable of reliablydetecting cracks that are present in any orientation in the componentbeing inspected.

96-88: The Civil Aviation Authority should require thatonly personnel qualified in accordance with paragraph 2 and paragraph9 of Airworthiness Notice 94 are permitted to conduct NDT examinations.

96-89: The Civil Aviation Authority should ensure thatall holders of authorisations granted by them in accordance withparagraph 4.3 of Airworthiness Notice 94 are aware that such authorisationsexpired in November 1995.