# Cessna T303 Crusader, G-PUSI

## AAIB Bulletin No: 3/99 Ref: EW/C97/9/6 Category: 1.2

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| **Aircraft Type and Registration:** | Cessna T303 Crusader, G-PUSI |
| **No & Type of Engines:** | 2 Continental TSIO-520-AE piston engines |
| **Year of Manufacture:** | 1983 |
| **Date & Time (UTC):** | 28 September 1997 at 1515 hrs |
| **Location:** | 15 miles east of Oxford (Kidlington) Airport |
| **Type of Flight:** | Private |
| **Persons on Board:** | Crew - 1 - Passengers - None |
| **Injuries:** | Crew - None - Passengers - N/A |
| **Nature of Damage:** | Left engine destroyed and minor airframe damage |
| **Commander's Licence:** | Private Pilot's Licence |
| **Commander's Age:** | 58 years |
| **Commander's Flying Experience:** | 2,900 hours (of which 1,600 were on type) |
| | Last 90 days - 60 hours |
| | Last 28 days - 25 hours |
| **Information Source:** | AAIB Field Investigation |

### History of the flight

Whilst in cruising flight at 2000 feet, the pilot heard and felt a 'bang' from the left engine. The aircraft lurched to the left and the pilot saw heavy smoke coming from the top and bottom of the left engine nacelle. He initiated the shutdown procedure for the left engine but then observed that the left propeller was stationary and found that the propeller control lever would not move to the full feather position. However the pilot then managed to carry out a successful single engine approach and landing at Oxford Airport.

## Strip examination of the left engine

The engine, which had accumulated 167 hours and 40 minutes over 233 flights (sectors) since overhaul, was shipped by an aircraft maintenance organisation at Oxford Airport to the agency that had carried out the last overhaul of the engine. Following strip examination by the overhaul agency, during which the crankshaft was found to have separated into three sections, the AAIB was informed of the accident.

## AAIB examination

A detailed metallurgical examination was conducted on the failed components. This revealed that the crankshaft had initially failed by a fatigue mechanism resulting from service induced cyclic stresses at the rear end of the No 6 crankpin (Figure 1 and Photograph 1). The failure was at an inclined angle to the horizontal axis of the crankshaft, which had allowed the crankshaft to continue to run. However after some further aircraft flights, with the crankshaft failed at the rear of No 6 crankpin, a second failure had occurred at the rear end of No 5 crankpin. Immediately following this second crankshaft failure, the engine crankcase had ruptured resulting in the propeller and the front of the engine, including the No 6 cylinder, separating from the remainder of the engine. Despite this massive failure, all engine parts were retained within the cowlings.

Detailed visual and macroscopic examination of the surfaces of both the primary and secondary crankshaft fractures indicated the following:

(a) The initiation region on both fracture faces of the primary fracture at the rear end of the No 6 crankpin had been mechanically damaged after separation. This mechanical damage had destroyed all evidence within the crack initiation region, precluding determination of the cause of the fatigue crack initiation. From the nature of the mechanical damage to these primary fracture surfaces it was evident that the engine had completed a small number of cycles/flights, probably of the order of five, after the crankshaft had fractured at this position.

(b) From a fatigue progression band count on the primary fracture surface of the No 6 crankpin (Photograph 2) it was determined that approximately 150 +/- 20 'events' (ie engine cycles/flights) had occurred between the time that a fatigue crack 6 mm long had been present in the initiation region and the time that full fracture had occurred. However, it was not considered probable that the size of the crack, when the engine was last overhauled, would have permitted detection using the magnetic flow fluorescent particle crack detection technique which had been used.

(c) Less than twenty 'events' (engine cycles) were associated with the secondary fatigue failure at the No 5 crankpin, indicating that this cracking had started before complete separation had occurred at the No 6 crankpin.

A microsection was taken from the crankshaft material and examined. This revealed that the steel had a fine tempered martensitic microstructure, which appeared metallurgically satisfactory, and the shaft had been surface hardened by a nitriding process.

The pistons, piston pins, connecting rods, counter balance weights and the main, big end and small end bearings were examined in the premises of the overhaul organisation to determine whether any reciprocating or rotary components could have been malaligned and thus adversely affected the fatigue resistance of the crankshaft. No evidence of malalignment was found, all unusual wear observed having occurred rapidly, probably during the final flight. The rear end faces of the big ends of the connecting rods had been forced against the adjacent faces of the cranks at the primary fracture position of the No 6 crankpin, and also at the No 3 crankpin. Associated very rapid friction-induced wear had taken place resulting in local temperatures which had approached 300°C.

**Manufacturer's examination**

The stripped engine, together with the failed sections of the crankshaft, were therefore forwarded to the engine manufacturer for further examination. The manufacturer concluded that the main fracture had occurred outside the No 6 crankpin fillet radius which, from their experience and knowledge, was not normally an area subjected to high stress. The manufacturer concluded that the failure had initiated due to hard contact between the crank face and the side of the No 6 connecting rod which had induced localised high stresses. Their assessment of the No 6 crankpin fracture indicated that the crack had been present for a large number of flights, probably in excess of 100. A more precise count was not possible due to the damage of the origin area. However the manufacturer considered that it was very unlikely that this fracture had been present prior to the overhaul some 233 flights previously. Surface origin fatigue cracks had also occurred within severe rub marks caused by hard contact between the side of the connecting rod and crank cheeks at the crankpin of cylinder No 3. There were also surface origin fatigue cracks within rub marks on the cheeks of the cranks of cylinders Nos 4 and 5. An apparent contributory factor to the observed rubbing was insufficient clearance between the piston pins and the connecting rod small end bushes. This reduced clearance, the manufacturer considered, may have resulted in seizure between the piston pins and the connecting rod bushes under normal operating conditions, applying side loads to the affected connecting rods.

However, the initial examination conducted by the AAIB had not found any evidence of seizure having occurred between any of the piston pins and the connecting rod bushes, and a further examination when the engine was returned from the manufacturer confirmed this assessment.

**Further metallurgical examination**

In order to attempt to ascertain whether the primary fatigue crack had initiated before or after the overhaul, the section of the No 6 crankpin where the initial failure of the crankshaft had occurred was submitted to a third metallurgical laboratory for examination. The visible number of events were counted and found to be 124. Because of the damage to the crack origin area, the exact number of event bands from initiation to final failure could not be counted. However, by measuring the crack front progression distance for every 25 observed events, working towards the initiation point, a figure of 225 +/- 20% events was assessed as the approximate number of events from crack initiation to final failure. This assessment was considered reliable since the fatigue damage per event was very consistent, as was the rate of growth of the crack front against service life. In addition, prior to the initiation of a detectable crack there would have been an incubation period during which no crack would have been apparent. This final assessment compared with the 233 flights which this engine had accumulated since the overhaul and thus the derived range of 180 to 270 events was not sufficiently precise to positively indicate whether the primary fatigue crack had originated before, or after, the overhaul.

**Examination of the left propeller**

The left propeller was taken to a manufacturer's approved overhaul agency and a static balance and examination carried out. The static balance results were found to be slightly in excess of the manufacturer's overhaul limits, but consistent for a propeller that had flown 264 hours since overhaul. The propeller mechanism was found to be in a serviceable condition and no evidence of damage or associated repair was found on the blade leading edges. It was noted that the blades were the same serial numbers as those recorded in the associated log books when the aircraft had been imported into the United Kingdom in 1988.

**Engine overhaul**

This engine had been sent to the UK overhaul organisation for its first overhaul in December 1996, having achieved 1930.5 hrs as the original engine fitted to this aircraft by Cessna. During this overhaul three experienced Non-Destructive Technique (NDT) technicians, who were qualified to conduct magnetic flow fluorescent particle crack detection inspections (MPI), had carried out three separate MPI's on the crankshaft (these MPI's were conducted in accordance with the engine manufacturer's inspection procedures) using two different, and correctly calibrated MPI equipments, at two different MPI facilities, and no cracks were detected.

**Aircraft usage**

The aircraft had flown 1850 hrs since it had been imported into the United Kingdom, 1600 hrs of which had been flown by the pilot on the incident flight. The majority of the flights were in connection with the owner's profession and it is understood that at no time during the aircraft's operation on the United Kingdom register had it been used for commercial flight training. Examination of the airframe, left engine and propeller log books showed no evidence that a propeller strike or sudden engine stoppage had occurred since the aircraft had been imported into the United Kingdom.