

Piper PA-38-112, G-BNSL, 24 June 1999

AAIB Bulletin No: 4/2000 **Ref:** EW/G99/06/28 **Category:** 1.3

Aircraft Type and Registration: Piper PA-38-112, G-BNSL

No & Type of Engines: 1 Lycoming O-235-L2C piston engine

Year of Manufacture: 1981

Date & Time (UTC): 24 June 1999 at 1305 hrs

Location: Edinburgh Airport

Type of Flight: Private

Persons on Board: Crew - 1 - Passengers - 1

Injuries: Crew - None - Passengers - None

Nature of Damage: Noseleg failed

Commander's Licence: Private Pilot's Licence with IMC and Night Ratings

Commander's Age: 57 years

Commander's Flying Experience: 335 hours (of which 206 were on type)

Last 90 days - 12 hours

Last 28 days - 8 hours

Information Source: Aircraft Accident Report Form submitted by the pilot and metallurgical examination by AAIB

History of the flight

The aircraft had been used for a flight from Edinburgh to Campbeltown and back. No defects had been observed during the daily inspection performed before the first sector of the flight, but during initial taxi checks at Edinburgh it appeared to the pilot that the steering loads seemed heavy when turning to the right. However, during the later stages of taxiing before leaving Edinburgh and during all the manoeuvring on the ground at Campbeltown the steering appeared normal.

The aircraft returned to Edinburgh and the pilot was asked to land some way down Runway 24 for traffic reasons. During the late stages of the approach, and in the flare, considerable turbulence was encountered but a touchdown without drift was accomplished. However as the nosewheel was lowered onto the runway the aircraft 'juddered and jerked', and so the pilot immediately applied full power and raised the nose to go round again. A circuit was flown and the pilot was again asked to land some way down the runway. During the final approach for this second landing, the pilot heard a rattling noise, which seemed to come from the nose area.

The second touchdown was made in smoother conditions than the first, but immediately after the nosewheel was lowered onto the runway it juddered again and the aircraft pulled hard to the left. Despite full right rudder being applied, the aircraft ran off the side of the runway onto the grass, which was boggy and had furrows running parallel to the runway; after the aircraft had run some 20 metres across the grass, the nose landing gear collapsed.

Detailed examination of the broken oleo strut cylinder

The nose oleo strut cylinder was found to have broken just above the lower swivel bearing journal, as shown in Figure 1. The two parts of the cylinder were sent to the AAIB for further examination and metallurgical examination. This revealed that the final failure of the cylinder had been the result of a high load application which had exploited a pre-existing tension fatigue crack. This crack had propagated from the change in thickness of the cylinder bore wall at the lower end of the oleo piston upper guide and had marginally reduced the cylinder's bending strength (see Figure 2 and Figure 3). The fatigue had initiated in the bore within the forward arc of the cylinder, the section which experiences the greatest tensile stress as a result of high wheel drag loads. Metallurgical examination of the steel microstructure in the area of failure revealed the presence of adverse grain flow associated with a forging 'flash line' which had reduced the fatigue strength of the component.

At the time of this metallurgical examination, the opportunity was taken to inspect the corners of the external lubrication groove in the lower swivel journal of the oleo for cracking, which had been the subject of an earlier AAIB Recommendation (93/07). The presence of fatigue cracking was detected in both the upper and lower corners of this groove on the cylinder from G-BNSL.

The AAIB Recommendation 93-07, which was formulated as a result of two previous fatigue related nose gear leg failures (in 1991 and 1992), had been accepted by the CAA, the FAA and Piper. The manufacturer had addressed this lubrication groove cracking by revising the Maintenance Manual (MM), adding a requirement for a dye penetrant inspection of the 'Nose Gear Strut Housing' in a revision of the MM dated 1 September 1993. The CAA accepted the associated advice from the FAA that this action was considered sufficient to address that particular cracking problem.

On the oleo cylinder from G-BNSL, the fatigue cracking present in the lubrication groove had clearly not yet reached a critical length which substantially reduced the bending strength of the leg and it could not be determined how long these cracks would have remained at sub-critical lengths, assuming that required dye-penetrant inspections would have taken place at the required intervals. The crack from the inner bore, however, which was exploited in this noseleg failure could not have been discovered by the existing dye penetrant inspection of the external lubrication groove. In addition, the fact that this fatigue crack from the internal bore was exploited to failure before those cracks which were present in the lubrication groove suggested that the bore crack was in a more critical location.

It was also discovered that the procedure to perform the dye penetrant inspection on the corners of the lubrication groove did not appear to be included in the current revision of the PA-38 Maintenance Manual and so further enquiries were made on this aspect.

Revisions of the PA38 Maintenance Manual following AAIB Recommendation 93-07

The procedure to inspect the corners of the lubrication groove was issued at an 'Interim Revision' to the MM, dated 1 September 1993. In that revision, the inspection was listed as Item 3 of the Landing Gear Group Periodic Inspections on Page 5-08, and referred to Note 37 on page 5-11. Item 3 was described as affecting the 'Nose Gear Strut Housing', but no Part Number reference was given. In this list, Item 3 was the one before that which required the aircraft to be placed on jacks to perform the subsequent inspections. The inspection was also listed in the Table of Contents and Effectivity of the Landing Gear, Chapter (32), and the inclusion of the procedure resulted in revisions to Pages 32-06, 32-08 & 32-09 of the MM. The actual procedure for 'Dye Penetrant Inspection of Nose Gear Strut Housing' was described on page 32-08, following descriptions of the procedures to Remove, Disassemble, Clean, Inspect and Repair the 'Nose Gear Oleo' and thus, implicitly, applicable after the aircraft had been placed on jacks.

The current revision of the MM was issued on July 15 1998. In this revision the inspection was listed at Item 13 of the Landing Gear Group Periodic Inspections on Page 5-08, and still referred to Note 37 on page 5-11. Item 13 was again described as affecting the Nose Gear Strut Housing, but with a Part Number reference then given. The change to Item 13 placed it after the point at which the aircraft was required to be put on jacks. The inspection was still listed in the Table of Contents and Effectivity of Chapter 32 (which remained the Interim Revision of Sept 93) and although the Interim Revision of Page 32-06 was still included, Pages 32-08 and 32-09 had reverted to an earlier revision state, as at June 23 1981, and so no procedure for 'Dye Penetrant Inspection of Nose Gear Strut Housing' was described in the Landing Gear Chapter (32) of the MM.

It was also noted that a potential source of confusion resulted from the description of the part to be inspected as the 'Nose Gear Strut Housing'. This form of words accords with that used in the Parts Catalogue when related to the Part Number given in the July 98 revision. However, in both Nose Oleo Strut illustrations and in all the text of Chapter 32 of the MM, apart from that sub-section which details the dye-penetrant inspection procedure, the part is described as the 'Cylinder'. In both Fig 32-3 (item 14) and Fig. 71-1 (item 15), of the MM the description 'Strut Housing' appears to refer exclusively to that part of the engine mounting assembly into which the nose oleo is fitted. As a result of inquiries conducted during this investigation it was established that some organisations have been inspecting the part on the engine mounting using the procedure laid down in the Interim Revision.

Safety recommendations

Three causes for concern were identified during this investigation; the omission from the current Revision of the Maintenance Manual of the dye penetrant inspection procedure for the repetitive inspection of the external lubrication groove in the lower swivel journal of the nose leg oleo strut cylinder, the potential for confusion of the Part to be inspected by this procedure; and the presence of another fatigue initiation site on the internal bore of the cylinder.

The PA38-112 Tomahawk is an aircraft type used extensively for training and when used in this role it is recognised that the landing gear will be exposed to inexperienced landings more likely to lead to a testing load cycle. In addition, occasional severe loading must be expected in any use. The likelihood of structurally weakening fatigue cracks in the nose landing gear of this type therefore require that it should be reliably monitored in service. Furthermore, the findings of this investigation indicate that fatigue cracks initiating in the nose leg oleo strut cylinder bore at the

location that occurred in this accident may be more critical than those in the external lubrication groove.

The following Safety Recommendations are therefore made:

Recommendation 2000-7

In order to ensure that fatigue cracks in the external lubrication groove of Piper PA-38 Tomahawk nose leg oleo strut cylinders are detected during the required repetitive dye penetrant inspections in service, the associated procedure in the Maintenance Manual, and all references to it, should be revised by New Piper Aircraft Inc. to eliminate any confusion regarding the description of the Part which is the subject of this inspection and re-instated in the Maintenance Manual.

Recommendation 2000-8

In order to ensure that potential fatigue cracks emanating from the internal bore of the nose leg oleo strut cylinder on Piper PA-38 Tomahawk aircraft are detected in service before leg failure occurs, the FAA in conjunction with New Piper Aircraft Inc. should devise and introduce a suitable in service inspection procedure to identify such cracking, or alternatively specify a service life for such strut cylinders.