Accident

Aircraft Type and Registration:	Piper PA-28-180, G-AXSG	
No & Type of Engines:	1 Lycoming O-360-A4A piston engine	
Year of Manufacture:	1970 (Serial no: 28-5605)	
Date & Time (UTC):	7 April 2023 at 0827 hrs	
Location:	St Mary's Airport, Isles of Scilly	
Type of Flight:	Private	
Persons on Board:	Crew – 1	Passengers – 2
Injuries:	Crew – None	Passengers – None
Nature of Damage:	Left main landing gear cylinder and torque link lugs fractured, damage to underside of flap and wing	
Commander's Licence:	Private Pilot's Licence	
Commander's Age:	79 years	
Commander's Flying Experience:	1,400 hours (of which 500 were on type) Last 90 days – 31 hours Last 28 days – 7 hours	
Information Source:	AAIB Field Investigation	

Synopsis

On touchdown the left main landing gear collapsed. The cause of the collapse was failure of both upper torque link attachment lugs on the landing gear cylinder due to fatigue cracking. There is a known history of fatigue cracking on cast landing gear cylinders and a manufacturer's Service Bulletin exists to regularly inspect the area around the attachment lugs. There is currently no Airworthiness Directive to mandate the Service Bulletin.

One Safety Recommendation is made to the CAA to ensure that the level of safety of cast main landing gear cylinders fitted to PA-28 and PA-32 aircraft is acceptable.

History of the flight

As the pilot applied the brakes after touching down, the aircraft veered to the left onto the grass where the left main landing gear leg collapsed. The remaining portion of the landing gear dug into the grass, turning the aircraft through 180° before it came to a stop (Figure 1). The pilot and passengers were uninjured.

Figure 1
G-AXSG following the landing

Aircraft information

The Piper PA-28 has a fixed, tricycle landing gear. Each main landing gear leg comprises a cylinder attached to the main wing spar; an oleo leg with a wheel and brake assembly; and upper and lower torque links. The torque links retain the oleo leg within the cylinder and prevent it from rotating. The upper torque link is connected to the man landing gear cylinder via two torque link attachment lugs (Figure 2). The same cylinder is fitted to some models of the PA-32 aircraft.

The main landing gear cylinder is aluminium alloy and can be manufactured either as a cast or a forged part. Casting requires the aluminium alloy to be heated until it becomes liquid, when it is then poured into a mould to form the component. The forging process heats the aluminium alloy to a plastic state where it is then shaped into the component using compressive forces. Forging typically results in a stronger component which is not as susceptible to fatigue cracking as the equivalent cast part.

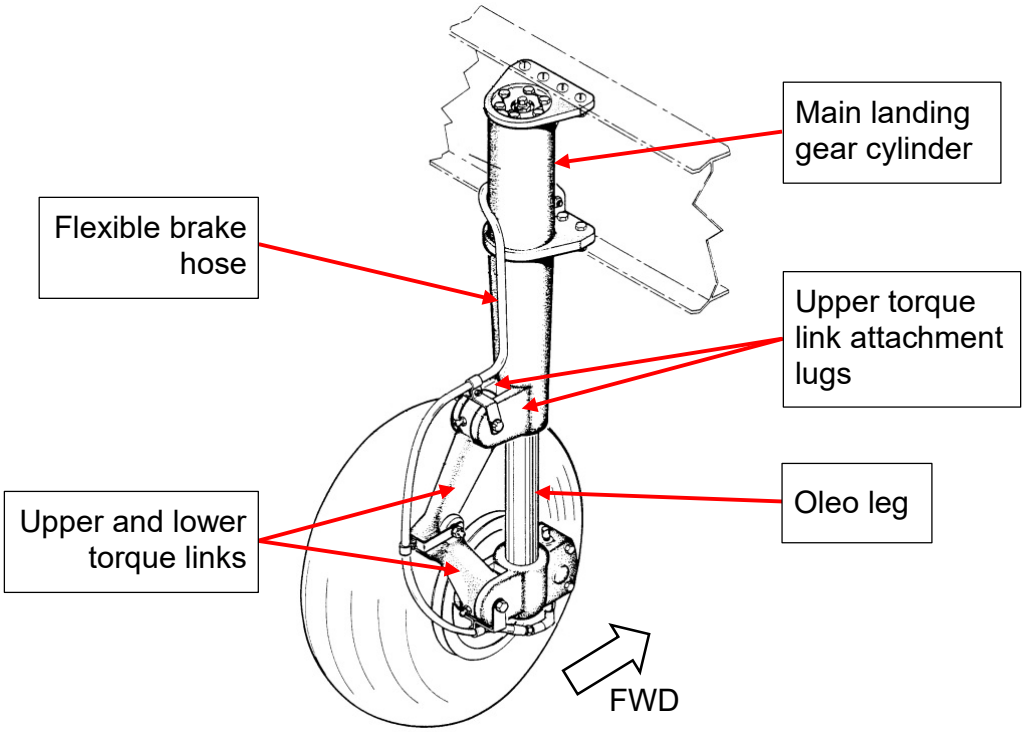

Figure 2

Left main landing gear leg assembly

Aircraft examination

The following damage was found on the aircraft:

- The left landing gear wheel, torque link and oleo strut assembly had detached from the landing gear cylinder but remained attached to the aircraft by the brake hose.
- The torque link attachment lugs had broken from the main landing gear cylinder and remained attached to the upper torque link (Figure 3).
- The base of the main landing gear cylinder had fractured into several smaller pieces near to the upper torque link attachment lugs (Figure 4).
- There was damage to the left flap and wing surface sustained from the oleo leg and wheel assembly during the accident sequence.
- The left wheel brake disc surface was corroded and did not show witness marks from the brake pad rubbing against the disc.

Figure 3

Detached torque link lugs and wheel assembly

Figure 4

Fractured lower left main landing gear cylinder fragments

Maintenance history

G-AXSG had a valid Airworthiness Review Certificate issued on 18 July 2022 at 8,044 hours. The last recorded annual inspection was conducted at the same time.

Following a report of the left main landing gear brake binding in February 2023, new piston seals were fitted and the brakes operated satisfactorily when tested.

Applicable Service Bulletins and Airworthiness Directives

Background

Fatigue cracking of the torque link attachment lugs is known to occur on the cast main landing gear cylinders fitted to PA-28 and PA-32 aircraft manufactured between 1961 and 1977. Aircraft manufactured since 1977 were fitted with a forged cylinder which can be used as a replacement for the cast cylinders.

Service Bulletins and Airworthiness Directives

Fatigue cracking of the torque link attachment lugs has been addressed within the UK and EU by a series of Airworthiness Directives (AD) and manufacturer's Service Bulletins[1] (SB) specifying inspections every 100 flight hours. Neither the SBs or ADs specified a calendar life or the maximum number of landings between inspection intervals.

The AAIB investigated a failure of a cast cylinder on a PA-28 (G-BRBA) on 4 September 2021 and the report contains the background to the SB and AD. In summary, CAA AD 002-06-99 was issued in 1999, followed by SB1131 in 2003 and updated by SB1131A in 2016. EASA AD 2005-0035, which mandated both SBs, was cancelled in 2020 by EASA due to the perceived low number of cast cylinders in service and the level of risk of failure. Currently, there is no AD to mandate SB1131A.

Inspection method

SB1131A called for a visual inspection before and after applying a liquid penetrant dye to the landing gear cylinder. However, the porosity of the aluminium alloy casting can produce a degree of background fluorescence when the dye is applied, making it difficult to differentiate small cracks from the porosity. With the cylinder fitted to the aircraft, access to the undersides of the upper torque link attachment lugs can be difficult and the effectiveness of visually identifying cracks is dependent on the level of lighting.

Compliance

SB1131A was last carried out on G-AXSG on 24 October 2019 at 7,948 hours with no record of any cracks having been detected. At the time of the accident the aircraft had flown a further 141 hours and completed 299 landings.

Footnote

[1] CAA Airworthiness Directive AD 002-06-99 (iss. 1999), Piper SB1131 (iss. 2003), EASA AD 2005-0035 (iss. 2005), and Piper SB1131A (iss. 2016).

Fracture surface examination

The fracture surfaces on the left main landing gear cylinder removed from G-AXSG were examined using a stereomicroscope and scanning electron microscopy.

The landing gear cylinder fractures were assessed to have occurred due to overload. They happened after the failure of the torque link lugs and detachment of the oleo leg and wheel assembly.

Both torque link attachment lug fracture surfaces showed an area of stable, progressive fatigue crack growth with faint striations[2] present. The fractures had initiated at the inner lower radii of each lug (Figure 5). The cracks reached a maximum depth of 2 mm on the inboard lug and 3 mm on the outboard lug before instantaneous fracture occurred. There was no evidence of pre-existing material or mechanical defects associated with the fatigue crack initiation.

Following the period of stable fatigue crack growth, the inboard lug showed evidence of having fractured in two stages. The first fracture (stage 1) extended to approximately three quarters of the lug's surface area, identified by slight oxidation of the fracture surface. Subsequent final separation of both the inboard and outboard lugs due to the secondary fracture (stage 2) are as assessed as having occurred at the same time.

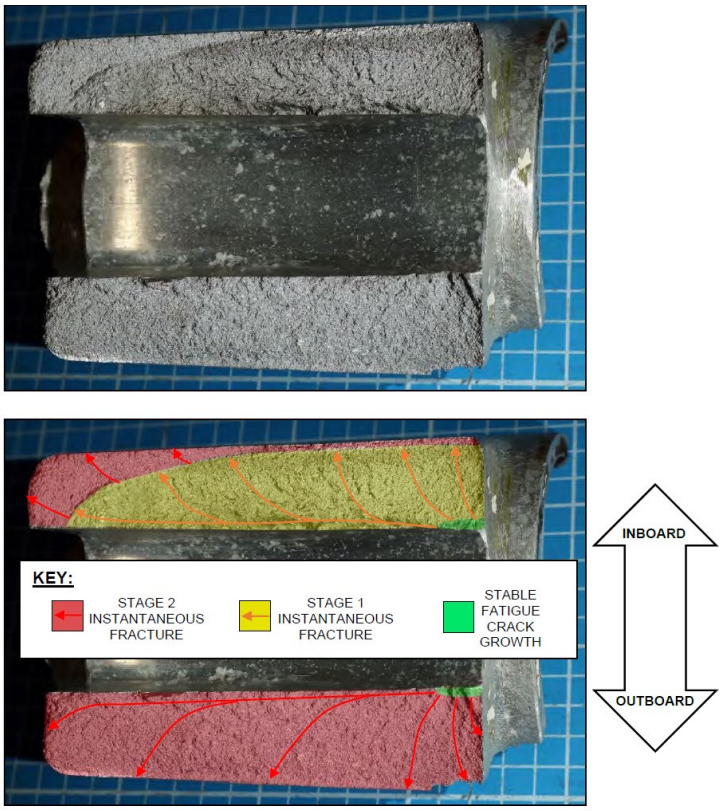

Figure 5

Torque link attachment lug fracture surface analysis

Footnote

[2] Marks on a fracture surface that indicate the incremental growth of a fatigue crack.

Brake function

The left main landing gear brake calliper was tested using an off-aircraft rig and found to operate normally. The brake pads showed evidence of light binding with the brake disc surface, but not to a level that would significantly affect rotation.

Assessment of unsafe condition

Within the UK, an aircraft component, part or system must initially demonstrate an acceptable level of safety in accordance with the requirements of UK Regulation (EU) No 748/2012. If subsequently, failures or defect reports indicate that this is no longer being achieved, an assessment can be made in accordance with Annex I Part 21.A.3 of the Regulation, to determine if an unsafe condition exists.

Analysis

The left landing gear torque link lugs failed on landing, resulting in the landing gear oleo, torque links and wheel assembly detaching from the main landing gear cylinder.

The fatigue cracks formed and grew from the inner lower radii of each lug, followed by instantaneous failure. Fine fatigue striations were present in the areas of stable crack growth on both lugs, but it was not possible to correlate them with the numbers of landings. It was also not possible to determine how long the inboard lug's first fracture had been present, prior to final fracture occurring. It is possible that the fatigue cracks were present at the last inspection, which was carried out while the leg was fitted to the aircraft, but were not detected using the dye penetrant inspection technique.

The last recorded compliance with SB1131A on G-AXSG was 141 flying hours prior to the accident, which was 41 hours beyond the recommended interval in SB1131A. The growth of fatigue cracks on the lugs is a function of the number of landings rather than flying hours and G-AXSG had completed 299 landings since the last inspection.

While SB1131A is still current, the EASA AD mandating it was cancelled in 2020 as EASA determined that an acceptable level of safety existed. Cast main landing gear cylinders are still fitted to aircraft and fatigue cracking of the lugs continues to occur. To ensure that an acceptable level of safety still exists for the cast cylinders fitted to PA-28 and PA-32 aircraft, and to provide appropriate guidance on inspecting the cylinders, the following Safety Recommendation is made to the CAA:

Safety Recommendation 2024-001

It is recommended that the Civil Aviation Authority undertakes an unsafe condition assessment, in accordance with the requirements of UK Regulation (EU) No 748/2012 Annex I Part 21.A.3, for the cast main landing gear cylinder cracking affecting PA-28 and PA-32 aircraft, and take appropriate action based on the outcome of the assessment.

Conclusion

The left main landing gear torque link attachment lugs failed due to fatigue cracking, causing the wheel assembly and oleo to come out of the landing gear cylinder on landing. While a SB exists to inspect the landing gear for fatigue cracking, the EASA AD mandating the inspection was cancelled in 2020 due to the perceived low number of cast aluminium cylinders in service and the level of risk of failure.

The SB was carried out on G-AXSG, with the landing leg still fitted to the aircraft. It is possible that the fatigue cracks were present but were not detected using the dye penetrant inspection technique.

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