

AAIB Bulletin No: 1/94

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Category: 1.2

Aircraft Type and Registration: Piper PA-31-350 Navajo Chieftain, G-VIPP

No & Type of Engines: 2 Lycoming TIO-540-J2BD piston engines

Year of Manufacture: 1979

Date & Time (UTC): 4 November 1993 at 1144 hrs

Location: Bristol (Filton) Airport, Avon

Type of Flight: Public Transport

Persons on Board: Crew - 2 Passengers - 5

Injuries: Crew - None Passengers - None

Nature of Damage: Damage to propellers, abrasion damage to fuselage underside

Commander's Licence: Airline Transport Pilot's Licence

Commander's Age: 28 years

Commander's Flying Experience: 2,192 hours (of which 344 were on type)
Last 90 days - 130 hours
Last 28 days - 43 hours

Information Source: AAIB Field Investigation

The pilot, accompanied by an assistant, had flown from Filton to Hawarden with passengers earlier in the day. The flight was uneventful and following a turn-around the pilot took off, with new passengers, for the return flight to Filton. After take off the gear retracted normally, but simultaneously both the pilot and his assistant noticed a 'paraffin' type smell which they could not identify, but which quickly disappeared.

For the approach to Filton, Runway 27 was in use and the weather was passed as follows: surface wind calm, visibility 2,500 metres in mist, cloud broken at 500 feet and overcast at 800 feet. The approach was normal until the aircraft intercepted the glide slope at 1,500 feet on QFE 1005 mb. At this point the pilot selected the gear down and asked his assistant to read the pre-landing checks. However, although the movement of the gear lever felt normal, the pilot noticed that neither the gear transit light nor the gear down lights had illuminated; additionally the gear lever had not returned to the neutral position and the pilot had not seen nor felt any indication that the gear had moved. After an unsuccessful attempt to recycle the gear, the pilot initiated a go-around and informed ATC that he had a gear problem. With ATC assistance the pilot then established a racetrack pattern in VMC conditions at 2,500 feet on QNH 1,011 mb. For the next hour he attempted to lower the gear using normal and

emergency procedures. During this time he also established a radio link to discuss the problem with an aircraft engineer, but all attempts to lower the gear were unsuccessful; at no time was there any indication that the gear had moved. Finally, the pilot carried out a fly-past of the ATC tower and observers informed him that the gear appeared fully up and that there was no indication of any hydraulic leak. He then re-established the aircraft on the racetrack pattern and briefed his assistant and the passengers on the gear-up landing and evacuation procedures. For the gear-up landing the pilot had decided to land on the main runway, rather than the grass, because he did not wish to manoeuvre the aircraft close to the ground, and because there were numerous obstructions in the grass areas; the weather had not changed significantly since his first approach. He agreed with ATC that he would carry out an ILS to a visual approach on Runway 27 and commenced his approach. At 500 feet on QFE 1005 mb he became visual with the runway, selected the master switch off, and the ground clearance switch on to retain radio contact with ATC. Subsequently, at approximately 50 feet to 100 feet agl, the pilot retarded the throttles, feathered the propellers, leaned the mixtures and pulled the fire wall shut-off valves. He held the aircraft off the runway while reducing speed and touched down gently just below 80 kt. Retardation was gradual and the aircraft remained on the centreline until it came to a stop. The crew and the passengers, who were uninjured, evacuated using all available exits. The AFS were already in attendance and quickly confirmed that the aircraft was secure.

Examination of aircraft

The aircraft was lifted onto a trailer and towed, with the landing gear still retracted and the gear doors closed, into a nearby hangar. The access doors on either side of the nose were opened and it was apparent that there was an excessive amount of hydraulic fluid on the floor of the bay. Some of this had exited via drain holes, causing the underside of the fuselage to be smeared with fluid. A cabin air intake was located aft of the drain holes; fluid taken in here most probably accounted for the 'paraffin' type smell in the cabin.

It was quickly established that the hydraulic fluid reservoir was empty and that the 'gear doors open' hydraulic pipe had separated at its connection to the left-hand side of the power pack, which is located in the nose bay. Attempts to lower the gear by operating the hand pump, following replenishment of the reservoir, merely resulted in fluid being discharged from the broken pipe.

The single hydraulic system on this type of aircraft operates the landing gear only, and is pressurised by a pump on each engine. A gear 'DOWN' selection electrically operates the door solenoid valve within the power pack, allowing fluid to be ported to the gear door actuators. Once the doors have opened, pressure continues to build until a priority valve opens to allow fluid to the landing gear actuators. Limit switches then cause the solenoid valve to operate in order to close the doors,

following which pressure again builds, causing another valve to open and resulting in the selector handle returning to the neutral position. An 'UP' selection is essentially a reverse of the foregoing, with similar sequencing operations. In the event of a leak between the pumps and the power pack, the gear can be lowered by means of a hand pump supplied from a protected volume of fluid drawn from further down the reservoir standpipe. The hand pump is ineffective if a leak occurs elsewhere in the system. There are no cockpit indications of either fluid contents or system pressure; neither is a 'free fall' gear lowering system provided.

It follows from the above description that if a leak occurs between the power pack and the gear door actuators, then *a)* the door actuators will not move, and *b)* there can be no build-up of pressure necessary to open the priority valve and permit the remainder of the gear lowering sequence to occur. It is probable that the pipe failure occurred during the previous gear retraction (the discharged fluid causing the reported smell in the cabin), with the reservoir contents subsequently being pumped overboard. The hand pump, when operated by the pilot, merely discharged its volume of fluid through the same break.

The pipe had failed close to its flared end (bellmouth); thus there was nothing to retain it within the nut and collar assembly that was attached to the male connector on the hydraulic pack. The component, Part No 40833-00, 'Tube Assy, Hyd Door Open', was removed from the aircraft and examined by the Materials and Structures Department, DRA Farnborough.

The coupling was a typical hydraulic union in that the nut, when tightened onto the male connector, caused the bellmouth to become clamped between the olive and the collar, thereby forming a seal. The separated portion of the bellmouth, which was approximately 2 mm in length, was found within the nut. A photograph of the constituent parts of the coupling (excluding the male connector), together with the intact end of the pipe, is shown at Figure 1.

It was noted that the two fracture halves could not be mated together as the internal diameter of the separate fragment was greater than the outside diameter of the fractured end of the pipe. It was also noted that the separated portion had various steps and chamfers where it had been in contact with the threads in the nut, and with the 'lipped' end of the collar, although it was not possible to exactly reconcile these features with the surface angles on the fittings. It is possible that this reflected a continuing plastic deformation (due to tightening of the nut) following partial separation.

Examination of the separated portion of the pipe revealed that it had been considerably deformed in the axial direction, and it did not exhibit the smoothly curved bell shape evident at the undamaged end. The fracture had occurred where the tube wall was very thin compared with the nominal wall thickness

of 0.9 to 1.0 mm; this was measured as 0.12 to 0.18 mm on the separated portion and 0.2 to 0.3 mm on the major part of the pipe. The latter was sectioned longitudinally and the thinning of the tube wall towards the fracture was clearly visible (see Figure 2). The examination indicated that neither fatigue nor a material defect had played any part in the failure. The general appearance of the failure strongly suggested that the wall thinning effect was associated with a poorly executed flaring operation during manufacture.

The aircraft had flown a total of 4,876 hours at the time of the accident. The decals on the subject pipe assembly suggested that it had been fitted at aircraft build. There is normally no reason to disturb the union with the hydraulic power pack unless the latter is changed. The records indicated that this component had not been replaced since the initial issue of the UK Certificate of Airworthiness in 1986.

The CAA's SDAU database had a record of one similar event, occurring to a PA-31 aircraft in 1976. The gear failed to extend due to a pipe separating at its connection with the power pack. The reason given was '....probably due to poor bellling at manufacture', with the Part No being: 40812-00, 'Engine Pump Pressure'.

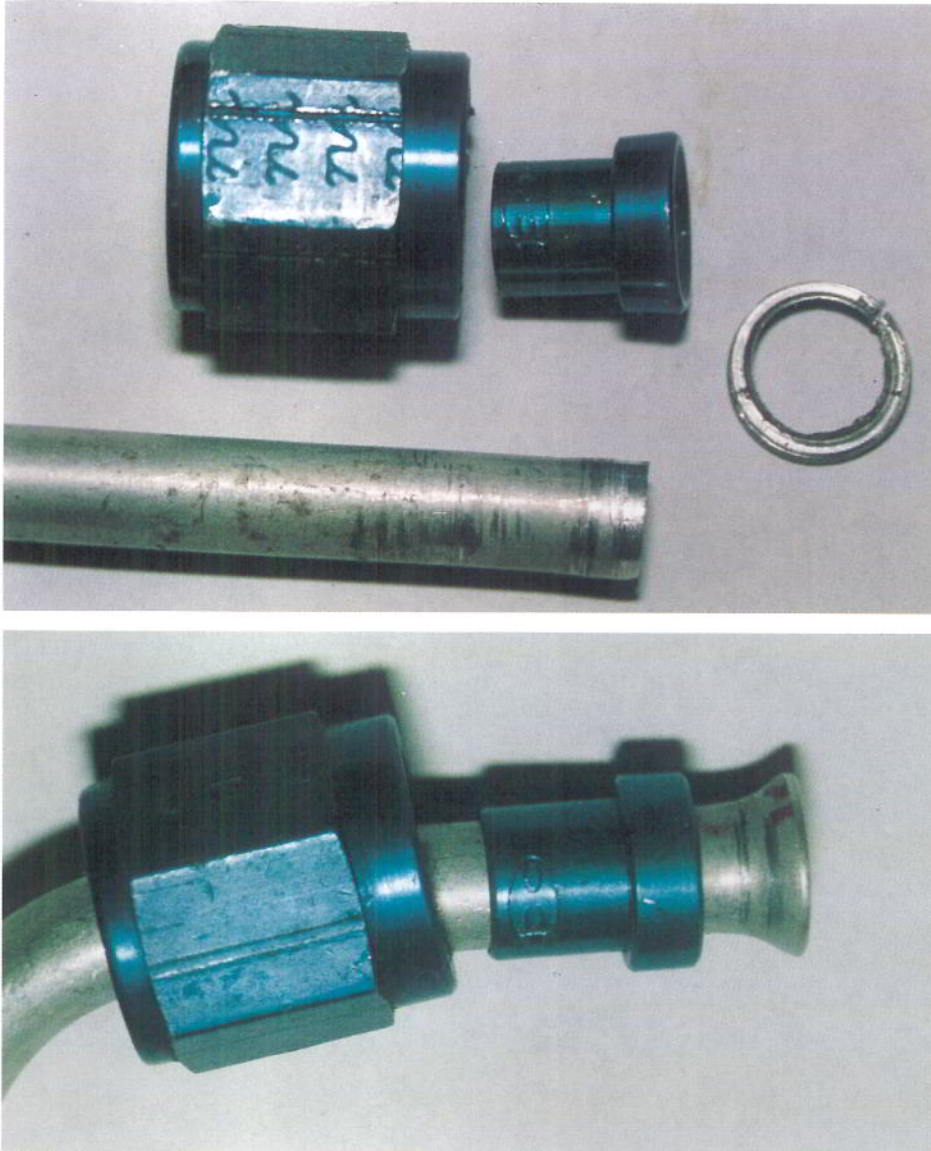


FIGURE 1. Failed end of pipe, showing detached section of bellmouth, together with intact end

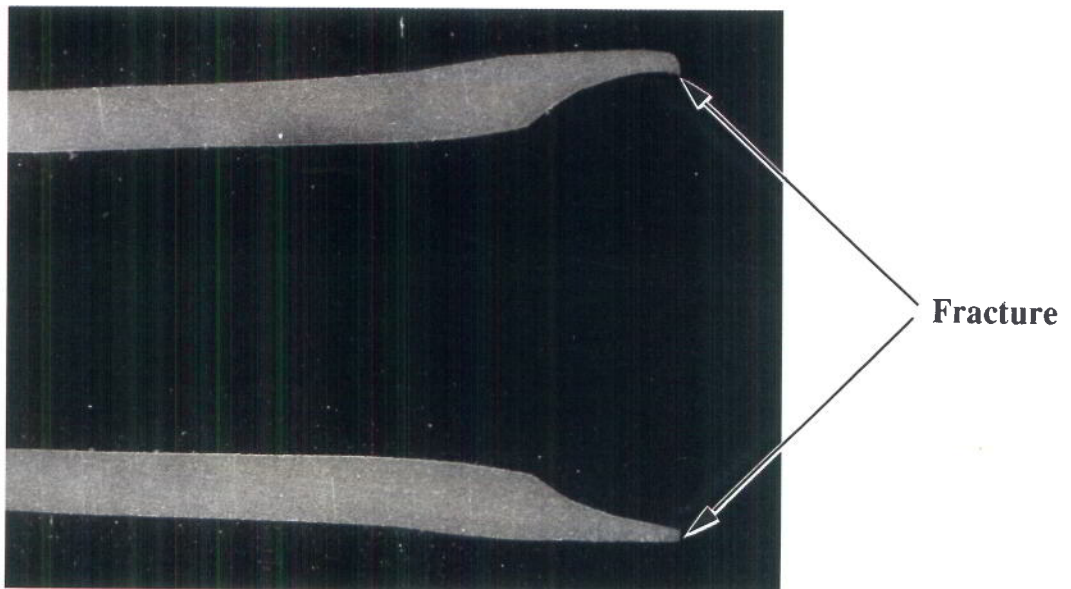


FIGURE 2. Section through failed pipe, showing wall thinning